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RESOURCE CONSERVATION AND RECOVERY FACILITY INVESTIGATION REPORT ZONE K VOLUME 2 OF 5 SECTION 10 CNC CHARLESTON SC

6/11/1999

ENSAFE INC.

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY
CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA
CTO-029

ZONE K
RCRA FACILITY INVESTIGATION REPORT

VOLUME II OF V
SECTION 10

SOUTHDIV CONTRACT
NUMBER: N62467-89-D-0318

Prepared for:

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA

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June 11, 1999
Revision: 0

10.0 SITE-SPECIFIC EVALUATIONS

10.1 SWMU 161, Vehicle Maintenance Shop, Naval Annex

SWMU 161 consists of a gravel parking lot, a vehicle maintenance and wash bay with grease pit, and Building 2505 (Figure 10.1.1). Building 2505 was constructed in 1960; some minor improvements were made in 1982 and 1989. The vehicle maintenance and wash bay and grease pit were added in 1993. This area is equipped with a drainage system and collection sump pumped to an 800- gallon oil-water separation unit. Waste oil from the separation process is stored in a 275 gallon AST. The Marine Corps has used the facility as a vehicle maintenance shop since the Navy took possession of the building from the Air Force in 1981. It is probable that the Air Force used the facility in a similar manner.

The gravel parking area adjacent to the south side of building is periodically occupied by heavy equipment such as backhoes and trucks. The parking area is stained with oil in places. Waste oil from the oil-water separation process was stored in fifteen 55-gallon drums on pallets during the Phase I site assessment.

According to the SWMU 161 RFA report water from the oil-water separator is discharged into the Naval Annex storm sewer. Based on a records review, it was determined that water from the separator discharges to the sanitary sewer system. Before the wash bay roof was constructed, the oil-water separator's contents would have overflowed into the storm water drainage system during heavy precipitation. The site's CSI status is justified by evidence of past releases to the storm water drainage system, the presence of the oil-water separator and associated sump and tank, the use of solvents to clean automotive parts, along with the presence of stained gravel/soil in the parking area.

Materials of concern identified in the approved final RFI work plan for SWMU 161 were solvents, metals, and petroleum products. Potential receptors are current and future site users involved in invasive activities.

To fulfill CSI objectives and confirm the presence of any contamination from onsite activities, soil and groundwater were sampled in accordance with the approved final RFI work plan and Section 3 of this report.

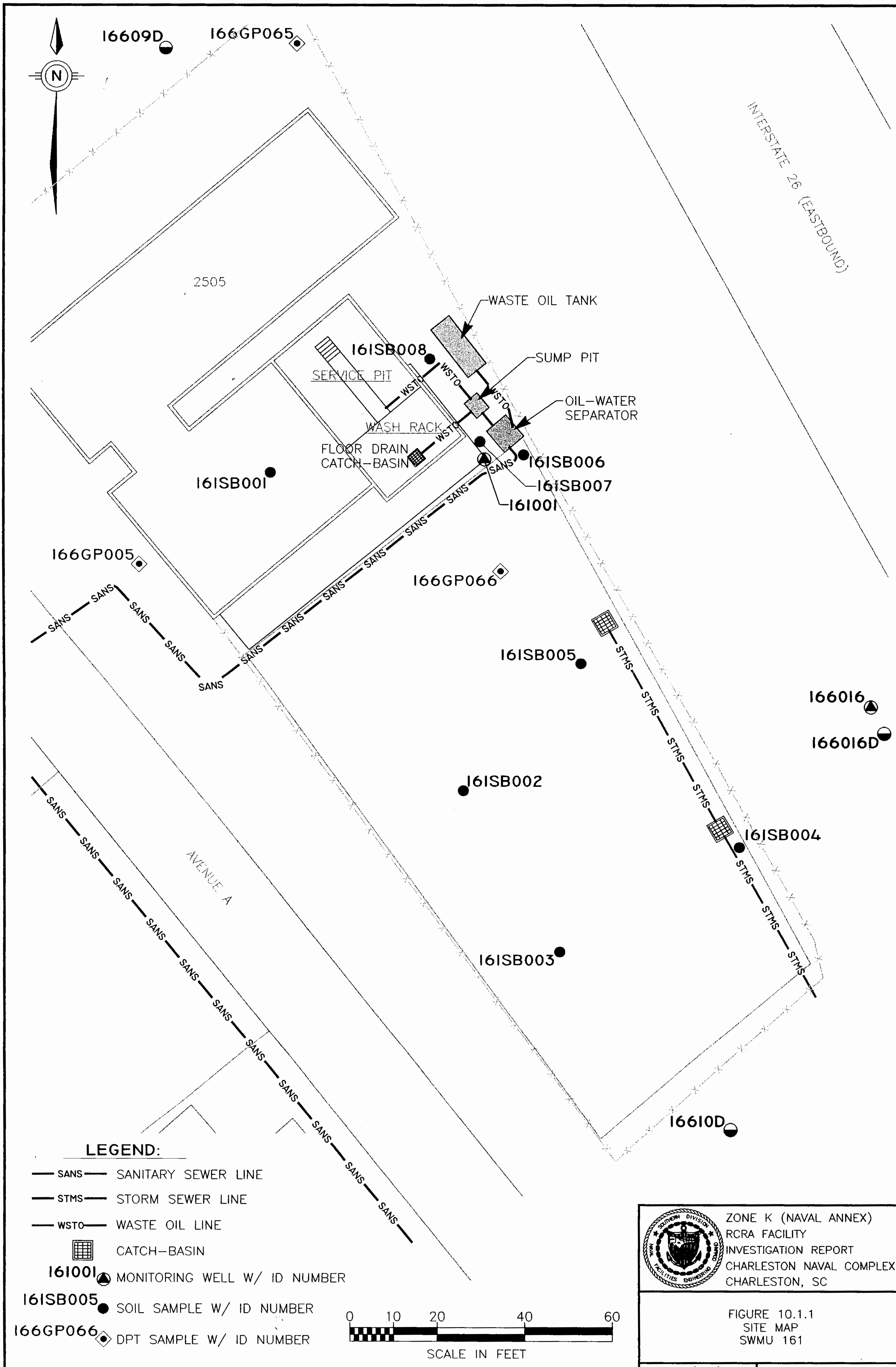
10.1.1 Soil Sampling and Analysis

Soil was sampled in one event at SWMU 161 from the locations shown on Figure 10.1.1. The final RFI work plan proposed collection of eight soil samples from the upper-interval (0 to 1 foot) and eight for the lower-interval (3 to 5 feet) for the SWMU 161 investigation area. All proposed samples were collected. First-round samples were submitted for analysis at DQO Level III for VOCs, SVOCs, metals, pesticides, PCBs, TPH, and cyanide. One duplicate was collected from boring 161SB02's lower-interval and submitted for Appendix IX analyses at DQO Level IV. Table 10.1.1 summarizes soil sampling for SWMU 161.

Table 10.1.1
SWMU 161
Soil Sampling Summary

Sampling Round	Sampling Date	Samples Collected	Sample Analyses	Comments
1	11/20/96	Upper - 8(8) Lower - 8(8) Duplicate - 1	Standard Suite, TPH Standard Suite, TPH Appendix IX, TPH	

Note:
( ) = Parentheses indicate number of samples proposed in the RFI Work Plan.
Standard Suite = VOCs, SVOCs, metals, cyanide, pesticides and PCBs at DQO Level III.
Appendix IX = Standard Suite, plus hex-chrome, dioxins, herbicides, and OP pesticides at DQO Level IV.


N
16609D
166GP065
INTERSTATE 26 (EASTBOUND)
2505
WASTE OIL TANK
SUMP PIT
OIL-WATER SEPARATOR
161SB008
SERVICE PIT
WASH RACK
FLOOR DRAIN CATCH-BASIN
161SB006
161SB007
161001
161SB001
166GP005
166GP066
161SB005
166016
166016D
161SB002
161SB004
AVENUE A
161SB003
16610D
LEGEND:
SANITARY SEWER LINE
STORM SEWER LINE
WASTE OIL LINE
CATCH-BASIN
161001 MONITORING WELL W/ ID NUMBER
161SB005 SOIL SAMPLE W/ ID NUMBER
166GP066 DPT SAMPLE W/ ID NUMBER
0 10 20 40 60
SCALE IN FEET
ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.1.1
SITE MAP
SWMU 161
Date: 06/02/99
DWG Name: 2911C054

10.1.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.1.2. Inorganic analytical results are summarized in Table 10.1.3. Table 10.1.4 summarizes all analytes detected in soil at SWMU 161. Analyte concentrations which exceeded their screening concentrations (the applicable residential soil RBC or SSL and, when available, the associated background concentration) are listed in bold type. Appendix F is a complete analytical data report for all samples collected in Zone K, including SWMU 161.

Table 10.1.2
SWMU 161
Organics Detected In Soil (μg/kg)

Parameter	Sample Interval	Detection	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBCs or SSL
Volatile Organic Compounds						
(16 Samples collected, 8upper-interval, 8 lower-interval, 1 lower-interval sample duplicated)						
Acetone	Upper	0/8	ND	ND	780,000	0
	Lower	2/8	7.0-8.0	7.5	8,000	0
1,2 Dichloroethane	Upper	0/8	ND	ND	7,000	0
	Lower	1/8	4.00	4.00	10	0
Semivolatile Organic Compounds						
(16 samples collected, 8 upper-interval, 8 lower-interval, 1 lower-interval sample duplicated)						
Di-n-butylphthalate	Upper	0/8	ND	ND	780,000	0
	Lower	1/8	100	100	2,300,000	0
Pesticides/PCBs						
(16 samples collected, 8 upper-interval, 8 lower-interval, 1 lower-interval sample duplicated)						
4,4' - DDE	Upper	3/8	4.30 - 6.83	5.55	1,900	0
	Lower	0/8	ND	ND	27,000	0
4,4 - DDT	Upper	2/8	10.80 - 13.50	12.15	1,900	0
	Lower	0/8	ND	ND	16,000	0
Total Petroleum Hydrocarbons - Diesel Range Organics (mg/kg)						
(16 Samples collected, 8 upper-interval, 8 lower-interval, 1 lower-interval sample duplicated)						
TPH-DRO	Upper	2/8	11.8 - 314	162.9	100[a]	1
	Lower	2/8	8.3 - 11	9.65	100[a]	0
Dioxin (ng/kg)						
(1 lower-interval duplicate sample)						
TCDD TEQ	Upper	0/0	NA	NA	4.3	NA
	Lower	1/1	.4637	.4637	1.600	0

Notes:

a = Charleston Naval Complex project screening level.
μg/kg = Micrograms per kilogram
ng/kg = Nanograms per kilogram
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined

Table 10.1.3
SWMU 161
Inorganics Detected In Soil (mg/kg)

Parameter	Sample Intervalal	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC & Background (upper) or SSL & Background (lower)
Inorganics							
16 Samples Collected; 8 Upper-interval, 8 Lower-interval, and One Lower-interval Duplicate							
Aluminum	Upper	8/8	5130 - 6630	5,963	11,200	7800	0
	Lower	8/8	2750 - 5470	4,134	10,500	560,000	0
Arsenic	Upper	8/8	0.69 - 1.9	1.0	3.00	0.43[a]	0
	Lower	4/8	0.41 - 0.73	0.56	1.98	15	0
Barium	Upper	8/8	5.5 - 16.8	10.0	25.6	550	0
	Lower	8/8	1.8 - 7.5	3.3	6.83	820	0
Beryllium	Upper	6/8	0.03 - 0.07	0.05	0.17	16	0
	Lower	1/8	0.03	0.03	0.12	32	0
Cadmium	Upper	1/8	0.11	0.11	0.13	3.9	0
	Lower	0/8	ND	ND	**	4	0
Calcium	Upper	8/8	2490 - 67400	16,719	NA	NL	NA
	Lower	8/8	64.8 - 22700	3,742	NA	NL	NA
Chromium	Upper	8/8	3.5 - 5.6	4.6	8.4	23	0
	Lower	8/8	3.1 - 4.7	3.8	8.76	19	0
Cobalt	Upper	4/8	0.17 - 1.5	0.6	0.34	470	0
	Lower	7/8	0.17 - 0.42	0.31	0.62	990	0
Copper	Upper	7/8	0.27 - 1.5	0.9	3.86	310	0
	Lower	7/8	0.23 - 0.88	0.41	0.34	5,600	0
Iron	Upper	8/8	2470 - 3250	2,864	7060	2300	0
	Lower	8/8	421 - 1710	990	5130	NL	0
Lead[b]	Upper	8/8	2.6 - 19.5	8.6	39.6	400[b]	0
	Lower	8/8	2 - 10	3	6.43	400[b]	0
Magnesium	Upper	8/8	111 - 1220	381	NA	NL	NA
	Lower	8/8	23.5 - 519	124	NA	NL	NA
Manganese	Upper	8/8	5.6 - 58.4	18.5	26.4	160	0
	Lower	8/8	3.2 - 25.6	6.6	5.93	480	0
Mercury	Upper	1/8	0.15	0.15	**	2.3	0
	Lower	0/8	ND	ND	**	1.0	0

Table 10.1.3
SWMU 161
Inorganics Detected In Soil (mg/kg)

Parameter	Sample Intervalal	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC & Background (upper) or SSL & Background (lower)
Nickel	Upper	8/8	1.3 - 3.6	2.2	1.70	160	0
	Lower	8/8	0.81 - 2.7	1.9	2.64	65	0
Potassium	Upper	8/8	33.3 - 246	94	NA	NL	NA
	Lower	8/8	17.2 - 100	42	NA	NL	NA
Selenium	Upper	1/8	0.44	0.44	0.84	39	0
	Lower	0/8	ND	NA	0.52	2.60	0
Silver	Upper	1/8	0.25	0.25	0.44	39	0
	Lower	0/8	ND	ND	0.42	17	0
Sodium	Upper	8/8	18.2 - 58.5	30.4	NA	NL	NA
	Lower	8/8	12.7 - 36	22	NA	NL	NA
Vanadium	Upper	8/8	6.6 - 8.4	7.6	15.8	55	0
	Lower	8/8	2.2 - 7.6	4.4	12.2	3,000	0
Zinc	Upper	1/8	5	5	14.8	2,300	0
	Lower	0/8	ND	ND	**	6,200	0

Notes:

a = RBC for arsenic as a carcinogen.
b = RBC not available for lead. USEPA residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).
** = Number of nondetects prevented determination of reference concentration.
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed
mg/kg = Milligrams per kilogram

Table 10.1.4
SWMU 161
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Volatile Organic Compounds (µg/kg)							
1,2-Dichloroethane	161SB004	ND	7,000	NA	4	10	NA
Acetone	161SB002	ND	780,000	NA	8	8,000	NA
	161SB006	ND			7		
Semivolatile Organic Compounds (µg/kg)							
Di-n-butylphthalate	161SB005	ND	780,000	NA	100	2,300,000	NA
Pesticides/PCBs (µg/kg)							
4,4-DDE	161SB005	4.3	1,900	NA	ND	27,000	NA
	161SB006	6.83			ND		
	161SB008	5.51			ND		
4,4-DDT	161SB006	10.8	1,900	NA	ND	16,000	NA
	161SB008	13.5			ND		
Dioxin Compounds (ng/kg)							
TCDD TEQ	161SB002	NT	4.3	NA	0	1,600	NA
1234678-HpCDD	161SB002	NT	430	NA	4.97	110,000	NA
OCDD	161SB002	NT	4,300	NA	414	1,100,000	NA
TPH-DRO (mg/kg)							
Diesel	161SB005	ND	100	NA	8.3	100	NA
	161SB006	11.8			11		
	161SB007	**314**			ND		

Table 10.1.4
SWMU 161
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Inorganics (mg/kg)							
Aluminum (Al)	161SB001	6,220	7,800	11,200	2,800	560,000	10,500
	161SB002	6,000			3,830		
	161SB003	5,450			5,470		
	161SB004	6,630			4,550		
	161SB005	5,970			2,750		
	161SB006	5,130			4,680		
	161SB007	6,460			4,050		
	161SB008	5,840			4,940		
Arsenic (As)	161SB001	0.85	0.43[a]	3	ND	15.0	1.98
	161SB002	0.69			0.6		
	161SB003	0.7			0.5		
	161SB004	1			ND		
	161SB005	0.94			ND		
	161SB006	1.1			ND		
	161SB007	1.1			0.41		
	161SB008	1.9			0.73		
Barium (Ba)	161SB001	10.5	550	25.6	1.8	820	6.83
	161SB002	8			2.2		
	161SB003	5.5			2.6		
	161SB004	9.2			3.4		
	161SB005	13.7			1.8		
	161SB006	16.8			4.5		
	161SB007	7.2			2.5		
	161SB008	9.1			7.5		

Table 10.1.4
SWMU 161
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Beryllium (Be)	161SB001	0.04	16	0.17	ND	32	0.12
	161SB004	0.06			ND		
	161SB005	0.07			ND		
	161SB006	0.03			ND		
	161SB007	0.04			ND		
	161SB008	0.07			0.03		
Cadmium (Cd)	161SB008	0.11	3.9	0.13	ND	4	NA
Calcium (Ca)	161SB001	2,490	NL	NA	64.8	NL	NA
	161SB002	7,770			2,030		
	161SB003	2,860			2,620		
	161SB004	9,390			772		
	161SB005	31,000			755		
	161SB006	2,990			384		
	161SB007	9,850			614		
	161SB008	67,400			22,700		
Chromium (Cr)	161SB001	4.7	23	8.4	3.7	19	8.76
	161SB002	4			3.2		
	161SB003	4.3			3.7		
	161SB004	5			3.6		
	161SB005	4.5			3.1		
	161SB006	3.5			4.4		
	161SB007	4.8			4		
	161SB008	5.6			4.7		

Table 10.1.4
SWMU 161
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Cobalt (Co)	161SB001	1.5	470	0.34	0.42	990	0.62
	161SB002	ND			0.17		
	161SB003	ND			0.25		
	161SB004	0.18			0.4		
	161SB005	0.17			ND		
	161SB006	ND			0.22		
	161SB007	ND			0.42		
	161SB008	0.51			0.28		
Copper (Cu)	161SB001	0.94	310	3.86	0.28	5600	0.34
	161SB002	0.27			0.33		
	161SB003	ND			0.35		
	161SB004	0.5			0.23		
	161SB005	0.92			0.56		
	161SB006	1.3			ND		
	161SB007	0.68			0.27		
	161SB008	1.5			0.88		
Iron (Fe)	161SB001	2,830	2,300	7060	467	NA	5130
	161SB002	2,650			666		
	161SB003	2,470			739		
	161SB004	3,090			1,480		
	161SB005	2,890			421		
	161SB006	2,960			1,610		
	161SB007	3,250			828		
	161SB008	2,770			1,710		

Table 10.1.4
SWMU 161
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Lead (Pb)	161SB001	5.8	400[b]	39.6	2.9	400[b]	6.43
	161SB002	4.1			2		
	161SB003	2.6			2.3		
	161SB004	6.2			2.5		
	161SB005	14.1			2.3		
	161SB006	19.5			3		
	161SB007	4			2.5		
	161SB008	12.3			10		
Magnesium (Mg)	161SB001	196	NL	NA	23.5	NL	NA
	161SB002	219			62.5		
	161SB003	111			66.1		
	161SB004	309			89.3		
	161SB005	517			67.2		
	161SB006	171			95.9		
	161SB007	304			68.5		
	161SB008	1,220			519		
Manganese (Mn)	161SB001	10.1	160	26.4	3.8	480	5.93
	161SB002	10.6			3.2		
	161SB003	5.6			3.5		
	161SB004	14			3.8		
	161SB005	29.5			3.3		
	161SB006	7.4			5.7		
	161SB007	12.2			3.7		
	161SB008	58.4			25.6		
Mercury (Hg)	161SB003	0.15	2.3	NA	ND	1	NA

Table 10.1.4
SWMU 161
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Nickel (Ni)	161SB001	2.7	160	1.7	0.81	65	2.64
	161SB002	1.7			1.4		
	161SB003	1.3			2.5		
	161SB004	2.2			2.7		
	161SB005	2.6			0.89		
	161SB006	1.4			2.3		
	161SB007	2			2.2		
	161SB008	3.6			2.4		
Potassium (K)	161SB001	95.8	NL	NA	17.2	NL	NA
	161SB002	60			23.4		
	161SB003	33.3			29.6		
	161SB004	73.9			49.6		
	161SB005	124			31.3		
	161SB006	43.4			39.7		
	161SB007	77.1			42.1		
	161SB008	246			100		
Selenium (Se)	161SB006	0.44	39	0.84	ND	2.6	0.52
Silver (Ag)	161SB004	0.25	39	0.44	ND	17.0	0.42
Sodium (Na)	161SB001	27.5	NL	NA	12.7	NL	NA
	161SB002	27.9			13.3		
	161SB003	25.5			25.2		
	161SB004	27.3			22.3		
	161SB005	29.4			15.1		
	161SB006	18.2			27.1		
	161SB007	29.1			20.6		
	161SB008	58.5			36		

Table 10.1.4
SWMU 161
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Vanadium (V)	161SB001	7.7	55	15.8	2.9	3,000	12.2
	161SB002	7			2.9		
	161SB003	6.6			3.6		
	161SB004	8.4			6		
	161SB005	7.7			2.2		
	161SB006	7.5			7.6		
	161SB007	8			4.3		
	161SB008	7.7			6.1		
Zinc (Zn)	161SB001	5	2300	14.8	ND	6,200	NA

Notes:
Bold concentrations exceed the RBCs, SSL, and the zone background
All background values for Zone K are based on twice the means of the grid sample concentrations.

DAF = Dilution attenuation factor
NA = Not applicable/not available
ND = Not detected/not determined
NT = Not taken
RBC = Risk-based concentration
SSL = Soil screening level
THQ = Target hazard quotient
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
ng/kg = Nanograms per kilogram

Volatile Organic Compounds in Soil

Two VOCs (acetone and 1,2-dichloroethane) were detected in soil samples collected at SWMU 161. Neither one exceeded its RBC screening concentration. All VOC detections were in lower-interval soil samples.

Semivolatile Organic Compounds in Soil

One SVOC (di-n-butylphthalate) was detected in a lower-interval soil sample collected at SWMU 161. No SVOCs were detected in the upper-interval soil samples. The concentration of di-n-butylphthalate was four orders of magnitude less than its RBC.

Pesticides/PCBs in Soil

Two pesticides (4,4'-DDE and 4,4'-DDT) were detected in upper- interval soil samples at SWMU 161. No pesticides were detected in the lower-interval soil samples. All pesticide concentrations were below their RBC screening concentrations.

No PCBs were detected in the SWMU 161 soil samples.

Other Organic Compounds in Soil

TPH-Diesel Range Organics (DROs) were detected in two of eight upper-interval and two of eight lower-interval samples. One TPH-DRO concentraion, 314 mg/kg, which was collected from a surface soil sample location (161SB007) exceeded the CNC screening level (100 mg/kg). TPH-DRO concentrations below the screening level were detected in the upper-interval and lower-interval samples at 161SB006 and the lower- interval sample at 161SB005.

Dioxin was detected in the one duplicate sample. The TCDD TEQ for the dioxin detection was several orders of magnitude below the RBC screening concentration.

Inorganics in Soil

Several inorganic analytes were detected in SWMU 161 soil samples. Arsenic and iron exceeded their RBCs. However, all arsenic and iron concentrations were below their respective surface and subsurface soil background concentrations.

10.1.3 Groundwater Sampling and Analysis

The final RFI work plan proposed the installation of one shallow monitoring well for SWMU 161. This well (NBCK161001) was installed adjacent to the oil-water separator in the northeastern corner of the property (Figure 10.1.1).

This monitoring well was developed in December 1996, and the first round of groundwater samples was collected from in January 1997 and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and TPH at DQO Level III. A duplicate sample was also collected from NBCK161001 and submitted for herbicide, dioxin, organophosphorus pesticide, and hexavalent chromium analyses, in addition to the standard suite of analyses.

Second-round groundwater for SWMU 161 was also analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and TPH at DQO Level III. Second-round samples were collected by the CEERD in April 1997. Third-round and fourth-round samples were collected in July and October 1997, and analyzed for VOCs, SVOCs, metals, cyanide, pesticides, and PCBs. Duplicate samples were also collected from NBCK161001 during each of these rounds. Fifth-round samples were collected for dioxins and TSS to confirm the dioxin detection in the first-round duplicate sample. Filtered and unfiltered samples were analyzed to determine the potential effects of suspended solids on groundwater dioxin results. Table 10.1.5 summarizes groundwater sampling at SWMU 161.

Table 10.1.5
SWMU 161
Groundwater Sampling Summary

Sampling Round	Sampling Date	Wells Sampled	Sample Analyses	Comments
1	1/3/97	161001[a]	Standard Suite and TPH	
2	4/18/97	161001[b]	Standard Suite and TPH	
3	7/25/97	161001[b]	Standard Suite	
4	10/22/97	161001[b]	Standard Suite	
5	1/9/99	161001	Dioxins, TSS	Filtered and unfiltered samples taken for dioxins

Notes:
a = Duplicate sample collected and analyzed for Appendix IX parameters and TPH.
b = Duplicate sample collected and analyzed for same parameters.
Standard suite = VOCs, SVOCs, metals, cyanide, pesticides, and PCBs, at DQO Level III.
Appendix IX = Standard Suite plus hex-chrome, dioxins, herbicides, and OP Pesticides at DQO Level IV.

The monitoring well was installed at 16 feet bgs in the water table aquifer. The well was installed as described in Section 3.3 of this report.

10.1.4 Nature and Extent of Contamination in Groundwater

Table 10.1.6 summarizes organic groundwater analytical results and Table 10.1.7 summarizes groundwater inorganic analytical results for SWMU 161. Table 10.1.8 summarizes all analytes detected in shallow groundwater at SWMU 161. Appendix F is a complete analytical data report for all samples collected in Zone K, including those collected at SWMU 161.

Table 10.1.6
SWMU 161
Organics Detected In Groundwater (pg/L)

Parameter	Sampling Round	Detection	Detection Range	Mean	Tap-water	Number of Samples Exceeding RBC or MCL
Dioxins						
TCDD TEQ	First	1/1	0.0069	NA	0.45/30	0
	Second	0/1	NA	NA	NA	
	Third	NA	NA	NA	NA	
	Fourth	NA	NA	NA	NA	
	Fifth	0/1	ND	NA	0	

Notes:
NA - Not applicable/not available/not analyzed
pg/L - Picograms per liter

Table 10.1.7
SWMU 161
Inorganics Detected In Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and background
Inorganics (1 Shallow groundwater sample collected during each event)							
Aluminum	First (Jan. 97)	1/1	540	540	3,700/50	471	1
	Second (April 97)	0/1	ND	ND			0
	Third ((July 97)	1/1	381	381			0
	Fourth (Oct. 97)	1/1	674	674			1
Barium	First (Dec. 95)	1/1	16.4	16.4	260/2,000	31.2	0
	Second (April 97)	1/1	17.5	17.5			0
	Third ((July 97)	1/1	14.15	14.15			0
	Fourth (Oct. 97)	1/1	13.75	13.75			0
Calcium	First (Dec. 95)	1/1	50,300	50,300	NL/NL	NA	NA
	Second (April 97)	1/1	30,800	30,800			NA
	Third ((July 97)	1/1	48,600	48,600			NA
	Fourth (Oct. 97)	1/1	45,750	45,750			NA
Copper	First (Dec. 95)	0/1	ND	ND	150/1,000	2.81	0
	Second (April 97)	0/1	ND	ND			0
	Third ((July 97)	1/1	1.7	1.7			0
	Fourth (Oct. 97)	0/1	ND	ND			0

Table 10.1.7
SWMU 161
Inorganics Detected In Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and background
Inorganics (1 Shallow groundwater sample collected during each event)							
Iron	First (Dec. 95)	1/1	150	150	1,100/300	235	NA
	Second (April 97)	1/1	285	285			NA
	Third ((July 97)	1/1	38.45	38.45			NA
	Fourth (Oct. 97)	1/1	88.1	88.1			NA
Lead	First (Dec. 95)	0/1	ND	ND	NL/15	1.94	0
	Second (April 97)	0/1	ND	ND			0
	Third ((July 97)	1/1	2.1	2.1			0
	Fourth (Oct. 97)	0/1	ND	ND			0
Magnesium	First (Dec. 95)	1/1	806	806	NL/NL	NA	NA
	Second (April 97)	1/1	1,730	1,730			NA
	Third ((July 97)	1/1	820.5	820.5			NA
	Fourth (Oct. 97)	1/1	685	685			NA
Manganese	First (Dec. 95)	1/1	6.9	6.9	73/50	9.33	0
	Second (April 97)	0/1	ND	ND			0
	Third ((July 97)	1/1	1.1	1.1			0
	Fourth (Oct. 97)	0/1	ND	ND			0
Potassium	First (Dec. 95)	1/1	985	985	NL/NL	NA	NA
	Second (April 97)	0/1	ND	ND			NA
	Third ((July 97)	1/1	447.5	447.5			NA
	Fourth (Oct. 97)	1/1	650.5	650.5			NA
Silver	First (Dec. 95)	1/1	1.6	1.6	18/100	NA	NA
	Second (April 97)	0/1	ND	ND			NA
	Third ((July 97)	0/1	ND	ND			NA
	Fourth (Oct. 97)	0/1	ND	ND			NA
Sodium	First (Dec. 95)	1/1	2,185	2,185	NL/NL	NA	NA
	Second (April 97)	0/1	ND	ND			NA
	Third ((July 97)	1/1	3,380	3,380			NA
	Fourth (Oct. 97)	0/1	ND	ND			NA
Zinc	First (Dec. 95)	0/1	ND	ND	1,100/5,000	NA	NA
	Second (April 97)	0/1	ND	ND			NA
	Third ((July 97)	1/1	26.75	26.75			NA
	Fourth (Oct. 97)	0/1	ND	ND			NA

Notes:
NA = Not applicable/not available/not analyzed
NL = Not Listed
ND = Not detected/not determined
μg/L = Micrograms per liter

Table 10.1.8
SWMU 161
Analytes Detected in Shallow Groundwater

Parameter	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Tap-water RBC/MCL	Shallow Background
Inorganics (μg/L) **(1 Shallow groundwater sample collected during each event)**							
Aluminum	161001	**539.5**	ND	381	**673.5**	3,700/50	471
Barium	161001	16.35	17.5	14.15	13.75	260/2,000	31.2
Calcium	161001	50,300	30,800	48,600	45,750	NA	NL/NL
Copper	161001	ND	ND	1.7	ND	150/1,000	2.81
Iron	161001	149.5	285	38.45	88.1	1,100/300	235
Lead	161001	ND	ND	2.1	ND	NL/15	1.94
Magnesium	161001	806	1,730	820.5	685	NA	NL/NL
Manganese	161001	6.85	ND	1.1	ND	73/50	9.33
Potassium	161001	984.5	ND	447.5	650.5	NL/NL	NA
Silver	161001	1.55	ND	ND	ND	18/100	NA
Sodium	161001	2,185	ND	3,380	ND	NL/NL	NA
Zinc	161001	ND	ND	26.75	ND	1,100/5,000	NA
Dioxins (pg/L)							
OCDD	161001	6.9	ND	ND	ND	450/NL	NA

Notes:
μg/L = Micrograms per liter
pg/L = Picograms per liter
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed

Volatile Organic Compounds in Groundwater

No VOCs were detected in groundwater samples collected at SWMU 161.

Semivolatile Organic Compounds in Groundwater

No SVOCs were detected in groundwater samples collected at SWMU 161.

Pesticides/PCBs in Groundwater

No pesticides or PCBs were detected in the groundwater sample collected at SWMU 161.

Other Organic Compounds in Groundwater

No herbicides, organophosphorus pesticides, or TPH concentrations were detected in the groundwater samples collected at SWMU 161. One dioxin congener(OCDD) was detected in the first-round groundwater sample at a concentration of 6.9 pg/L. The TEQ calculated for this location was 0.0069 pg/L

Inorganics in Groundwater

Several inorganics were detected in each of the four rounds of SWMU 161 groundwater samples. Only aluminum exceeded its SMCL and background concentrations. Aluminum concentrations ranged from 381 to 673 μg/L. However, all inorganic detections were below the applicable RBCs during all groundwater sampling rounds.

10.1.5 Fate and Transport Assessment for SWMU 161

Environmental media sampled as part of the SWMU 161 RFI are surface soil, subsurface soil, and shallow groundwater. Potential constituent migration pathways investigated for SWMU 161 are soil-to-groundwater, groundwater-to-surface-water, and emission of volatiles from surface soil-to-air.

10.1.5.1 SWMU 161 Soil to Groundwater Cross-Media Transport

Tables 10.1.9 and 10.1.10 compare maximum detected organic and inorganic constituent concentrations in surface soil and subsurface soil samples to risk-based soil screening levels considered protective of groundwater. To provide a conservative screen, generic soil screening levels are used; leachate entering the aquifer is assumed to be diluted by a ratio of 10:1, with no attenuation of constituents in soil (DAF=10).

Table 10.1.9
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, and Soil to Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: SWMU 161
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurfac Soil	Shallow GW	Screening Concentration * Soil to GW SSL	Tap Water RBC	Soil to Air SSL	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Volatil-ization Potential
Volatile Organic Compounds											
Acetone	ND	8	ND	8000	3700	1E+08	UG/KG	UG/L	NO	NO	NO
1,2-Dichloroethane (EDC) c	ND	4	ND	10	0.12	400	UG/KG	UG/L	NO	NO	NO
Semivolatile Organic Compounds											
Di-n-butylphthalate	ND	100	ND	2300000	3700	2300000	UG/KG	UG/L	NO	NO	NO
Pesticides/PCB Compounds											
4,4'-DDE c	6.83	ND	ND	27000	0.2	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDT c	13.5	ND	ND	16000	0.2	1.0E+09	UG/KG	UG/L	NO	NO	NO
Dioxin Compounds											
2378-TCDD Equivalents (TEQs)	NA	0.464	0.0069	1600 a	0.45	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDD c	NA	4.97	ND	110000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDD c	NA	414	6.9	1100000 a	450	NA	NG/KG	PG/L	NO	NO	NO
TPH - Diesel Range Organics											
Diesel	314000	11000	ND	NA	NA	NA	UG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.6
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.1.2 and 10.1.6.

a - Calculated soil to groundwater SSL value (See Table 6.x)
b - Based on surrogate compound; see table 5.6
c - Carcinogen
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration

SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.1.10
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, Soil to Air SSLs, and Background Reference Values
Charleston Naval Complex, Zone K, Naval Annex: SWMU 161
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurface Soil	Shallow GW	Screening Concentration Soil to GW SSL	Soil Background Reference	Soil to Air SSL	Tap Water RBC	GW Background Reference	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Fugitive Particulate Inhalation Concern
Inorganics													
Aluminum	6630	5470	674	560000 a	11200	NA	37000	471	MG/KG	UG/L	NO	NO	NO
Arsenic c	1.9	0.73	ND	15	3	750	0.045	NA	MG/KG	UG/L	NO	NO	NO
Barium	16.8	7.5	17.5	820	25.6	690000	2600	31.2	MG/KG	UG/L	NO	NO	NO
Beryllium	0.07	0.03	ND	32	0.17	1300	73	NA	MG/KG	UG/L	NO	NO	NO
Cadmium	0.11	ND	ND	3.8	0.13	1800	18	NA	MG/KG	UG/L	NO	NO	NO
Chromium (total)	5.6	4.7	ND	19 b	8.76	270	110	NA	MG/KG	UG/L	NO	NO	NO
Cobalt	1.5	0.42	ND	990 a	0.62	NA	2200	NA	MG/KG	UG/L	NO	NO	NO
Copper	1.5	0.88	1.7	5600 a	3.86	NA	1500	2.8	MG/KG	UG/L	NO	NO	NO
Lead	19.5	10	2.1	400 d	39.6	400	15	1.9	MG/KG	UG/L	NO	NO	NO
Manganese	58.4	25.6	6.9	480 a	26.4	NA	730	9.3	MG/KG	UG/L	NO	NO	NO
Mercury	0.15	ND	ND	1	NA	10	11	NA	MG/KG	UG/L	NO	NO	NO
Nickel	3.6	2.7	ND	65	2.64	13000	730	NA	MG/KG	UG/L	NO	NO	NO
Selenium	0.44	ND	ND	2.6	0.84	NA	180	NA	MG/KG	UG/L	NO	NO	NO
Silver	0.25	ND	1.6	17	0.44	NA	180	NA	MG/KG	UG/L	NO	NO	NO
Vanadium	8.4	7.6	ND	3000	15.8	NA	260	0.8	MG/KG	UG/L	NO	NO	NO
Zinc	5	ND	26.8	6200	14.8	NA	11000	NA	MG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.7
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.1.3 and 10.1.7.

Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migra

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Assumes hexachrome
c - Carcinogen
d - USEPA de facto residential soil level
GW - Groundwater
NA - Not available/Not applicable

ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

No SWMU 161 soil organics or inorganics exceeded their groundwater protection SSLs. Therefore, this pathway is considered invalid at SWMU 161.

10.1.5.2 SWMU 161 Risk-based Groundwater Transport

Table 10.1.9 and 10.1.10 also compare maximum detected organic and inorganic concentrations in shallow groundwater samples to risk-based concentrations for drinking water. To provide a conservative screen, no attenuation or dilution of in groundwater is assumed before comparison to the relevant standards.

No organics or inorganics in SWMU 161 groundwater exceeded risk-based drinking water concentrations. As a result, this pathway is not considered valid at SWMU 161.

10.1.5.3 SWMU 161 Soil-to-Air Cross-Media Transport

Table 10.1.9 also compares VOCs detected in SWMU 161 surface soil samples to corresponding soil-to-air volatilization screening levels. No VOC exceeded its soil-to-air volatilization screening level. As a result, the soil-to-air migration pathway is not expected to be valid at SWMU 161.

10.1.5.4 SWMU 161 Fate and Transport Summary

No contaminant fate and transport concerns were identified at SWMU 161.

10.1.6 Human Health Risk Assessment for SWMU 161

10.1.6.1 Site Background and Investigative Approach

SWMU 161 is the location of a vehicle maintenance shop at the Naval Annex. Materials released or disposed at the SWMU, which consists of a vehicle wash bay and an oil-water separator, include, petroleum products, metals, and solvents.

During the RFI, eight soil samples were collected from the upper and lower-intervals to identify potential impacts from the activities listed above. Surface and subsurface soil samples were analyzed for VOCs, SVOCs, metals, cyanide, pesticides, PCBs, and TPH. Surface soil data were used to quantitatively assess soil pathways. One monitoring well was installed in the shallow aquifer and sampled for the same parameters as soil. Data from the four quarterly sampling events were used to quantitatively assess groundwater exposure pathways. Sections 10.1.1 and 10.1.3 summarize the sampling effort for SWMU 161 soil and groundwater.

10.1.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.1.11, no COPCs were identified in surface soil samples collected at SWMU 161. However, diesel range TPH was detected at a concentration exceeding 100 mg/kg in one surface soil sample at SWMU 161 (161SB007). Arsenic was detected in surface soil samples at concentrations exceeding its RBC, but lower than its background concentration. As a result, arsenic was eliminated as a COPC based on comparison to its background concentration. Wilcoxon rank sum test analysis did not result in the inclusion of any parameter that had been screened out on the basis of background concentration.

Groundwater

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.1.12, no COPCs were identified in four quarters of groundwater samples collected at SWMU 161. Wilcoxon rank sum test analysis did not result in the inclusion of any parameter that had been screened out on the basis of background concentration.

Table 10.1.11
Chemicals Present In Site Samples
SWMU 161 - Surface Soil
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter	Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
TPH - Diesel Range Organics												
Diesel	2	8	11.8	314	162.9	2.61	2.75	100	NA	MG/KG		
Inorganics												
Aluminum (Al)	8	8	5130	6630	5963	NA	NA	7800	11200	MG/KG		
Arsenic (As)	8	8	0.69	1.9	1.04	NA	NA	0.43	3	MG/KG	8	
Barium (Ba)	8	8	5.5	16.8	10	NA	NA	550	25.6	MG/KG		
Beryllium (Be)	6	8	0.03	0.07	0.052	0.01	0.01	16	0.17	MG/KG		
Cadmium (Cd)	1	8	0.11	0.11	0.11	0.02	0.02	3.9	0.13	MG/KG		
Calcium (Ca)	8	8	2490	67400	16719	NA	NA	NA	NA	MG/KG		
Chromium (Cr)	8	8	3.5	5.6	4.55	NA	NA	23	8.4	MG/KG		
Cobalt (Co)	4	8	0.17	1.5	0.59	0.06	0.065	470	0.34	MG/KG		2
Copper (Cu)	7	8	0.27	1.5	0.87	0.085	0.085	310	3.86	MG/KG		
Iron (Fe)	8	8	2470	3250	2864	NA	NA	NA	NA	MG/KG		
Lead (Pb)	8	8	2.6	19.5	8.58	NA	NA	400	39.6	MG/KG		
Magnesium (Mg)	8	8	111	1220	381	NA	NA	NA	NA	MG/KG		
Manganese (Mn)	8	8	5.6	58.4	18.5	NA	NA	1100	26.4	MG/KG		2
Mercury (Hg)	1	8	0.15	0.15	0.15	0.025	0.03	2.3	NA	MG/KG		
Nickel (Ni)	8	8	1.3	3.6	2.19	NA	NA	160	1.7	MG/KG		6
Potassium (K)	8	8	33.3	246	94.2	NA	NA	NA	NA	MG/KG		
Selenium (Se)	1	8	0.44	0.44	0.44	0.19	0.205	39	0.84	MG/KG		
Silver (Ag)	1	8	0.25	0.25	0.25	0.09	0.1	39	0.44	MG/KG		
Sodium (Na)	8	8	18.2	58.5	30.4	NA	NA	NA	NA	MG/KG		
Vanadium (V)	8	8	6.6	8.4	7.58	NA	NA	55	15.8	MG/KG		
Zinc (Zn)	1	8	5	5	5	1.85	6.7	2300	14.8	MG/KG		
Pesticides												
4,4'-DDE	3	8	4.3	6.83	5.55	1.72	1.80	1900	NA	UG/KG		
4,4'-DDT	2	8	10.8	13.5	12.2	1.72	1.80	1900	NA	UG/KG		

Notes:
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/KG - micrograms per kilogram
MG/KG - milligrams per kilogram
NA - Not applicable or not available

Table 10.1.12
Chemicals Present in Site Samples
SWMU 161 - Shallow Groundwater
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter	Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
TCDD Equivalents												
Dioxin Equiv.	1	2	0.0069	0.0069	0.0069	0.003	0.003	0.45	NA	PG/L		
OCDD	1	2	6.9	6.9	6.9	3.273	3.273	450	NA	PG/L		
Inorganics												
Aluminum (Al)	3	4	304.5	673.5	506	153	153	3700	NA	UG/L		
Barium (Ba)	4	4	13.75	17.5	15.4	NA	NA	260	31.4	UG/L		
Calcium (Ca)	4	4	30800	50300	43863	NA	NA	NA	NA	UG/L		
Copper (Cu)	1	4	1.7	1.7	1.7	0.89	4.3	150	NA	UG/L		
Iron (Fe)	4	4	38.45	285	140	NA	NA	NA	NA	UG/L		
Lead (Pb)	1	4	2.1	2.1	2.1	0.89	1.9	15	NA	UG/L		
Magnesium (Mg)	4	4	685	1730	1010	NA	NA	NA	NA	UG/L		
Manganese (Mn)	2	4	1.1	6.85	4.0	2.2	8.5	73	15.5	UG/L		
Potassium (K)	3	4	447.5	984.5	694	661	661	NA	NA	UG/L		
Silver (Ag)	1	4	1.55	1.55	1.6	1.7	3.2	18	NA	UG/L		
Sodium (Na)	2	4	2185	3380	2783	2500	7500	NA	NA	UG/L		
Zinc (Zn)	1	4	26.75	26.75	26.8	4.6	60.2	1100	NA	UG/L		

Notes:
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/L - micrograms per liter
NA - Not applicable or not available

10.1.6.3 Risk Uncertainty

Soil Screening

A conservative screening process was used to identify COPCs for SWMU 161. The potential for eliminating CPSSs with the potential for a cumulative HI greater than 1 was addressed for noncarcinogens through the use of RBCs that were reduced one order of magnitude, equating with an HQ of 0.1. For carcinogens, the RBCs are based on a conservative target risk of 1E-06. Use Combining conservative RBCs with maxium detected concentrations minimizes the likelihood of a significant contribution to risk/hazard based on eliminated CPSSs. Of the CPSSs screened and eliminated from formal assessment, only arsenic was reported at concentrations exceeding its RBC (0.43 mg/kg), but was below its background reference value (3 mg/kg). No other soil constituent was reported at a concentration within 10% of its RBC.

Groundwater Screening

The same conservative screening process used for soil was also used for groundwater. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration within 10% of its RBC.

Background-related Risk

Arsenic was detected in SWMU 161 surface soil at concentrations exceeding its RBC. This element was eliminated from consideration in the risk assessment, however, based on comparison to its background concentration. It is not unusual for naturally occurring or background concentrations of some elements to exceed risk-based concentrations. It is the risk assessment's function to identify excess risk and/or hazard, or that which exceeds background levels. The following discusses of the residential scenario risk/hazard associated with background arsenic concentrations.

The maximum arsenic surface soil concentration (1.9 mg/kg) for SWMU 161 equates with an ILCR of 6E-06 for the site resident and 7E-07 for the site worker. Projected hazard quotients were estimated to be 0.09 and 0.004 for the residential child and site worker, respectively.

10.1.6.4 Risk Summary

No COCs were identified in surface soil or four quarters of groundwater samples at SWMU 161, indicating that there is no threat to human health at SWMU 161 via the surface soil or shallow groundwater exposure pathways.

10.1.7 Corrective Measures Considerations

For SWMU 161, the upper-interval and lower-soil intervals and shallow groundwater were investigated. In all, eight soil samples were collected to identify potential impact from activities conducted at the site. One groundwater monitoring well was installed from which four quarters of samples were collected. Based on the analytical results and the human health risk assessment, no COCs were identified as requiring further evaluation through the CMS process for the upper-soil interval or shallow groundwater.

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10.2 SWMU 162, Sludge Drying Field, Naval Annex

SWMU 162, a former sludge drying field at the Naval Annex, was used to dewater wastewater treatment sludge from an Air Force-operated sewage treatment plant. No information is available to characterize the Air Force waste stream. A soccer field has been constructed on the former sludge drying field area, which is bounded by Fifth and Sixth Streets, Air Street and D Avenue. Based on interviews with Navy and Air Force personnel, a liner may have been installed in the unit prior to use. No records or other evidence confirming this possibility have been located. Drawings reviewed at the CNC Public Works Department identified a sewage treatment plant adjacent to the sludge drying field at Fifth Street and D Avenue. Figure 10.2.1 identifies the location of the sludge drying field and the former sewage treatment facility, which was determined from CNC Maps #25713-24, March 6, 1968, and #25713-21. All Naval Annex records were throughly searched and no additional information pertinent to SWMU 162 was identified.

Materials of concern identified in the final RFI work plan for SWMU 162 are paint residue, heavy metals, and decomposition gases. Potential receptors are current and future site users involved in invasive activities.

To fulfill CSI objectives, soil and groundwater were sampled in accordance with the final RFI work plan and Section 3 of this report to confirm whether any contamination has resulted from onsite activities at SWMU 162.

10.2.1 Soil Sampling and Analysis

Soil was sampled in two rounds at SWMU 162 from the locations shown on Figure 10.2.1 as proposed in the final RFI work plan, that is five soil samples from the upper-interval (0 to 1 foot) and 5 from the lower-interval (3 to 5 feet).

The first round of sampling occurred during the field investigation for Zone K. Mercury was detected in two of the upper-interval soil samples collected at the site during the first round. As part of the Zone K second-round RFI sampling effort, four additional upper-interval soil samples were collected at SWMU 162.

First-round samples were submitted for analysis at DQO Level III for VOCs, SVOCs, metals, pesticides, PCBs, TPH, cyanide, nitrates, and sulfides. Two duplicates each were collected from borings 162SB03's and 162SB05's upper and lower-intervals, and submitted for Appendix IX analyses at DQO Level IV. Second-round samples were submitted for SVOC and metals analysis at DQO Level III. Table 10.2.1 summarizes first and second-round sampling for SWMU 162.

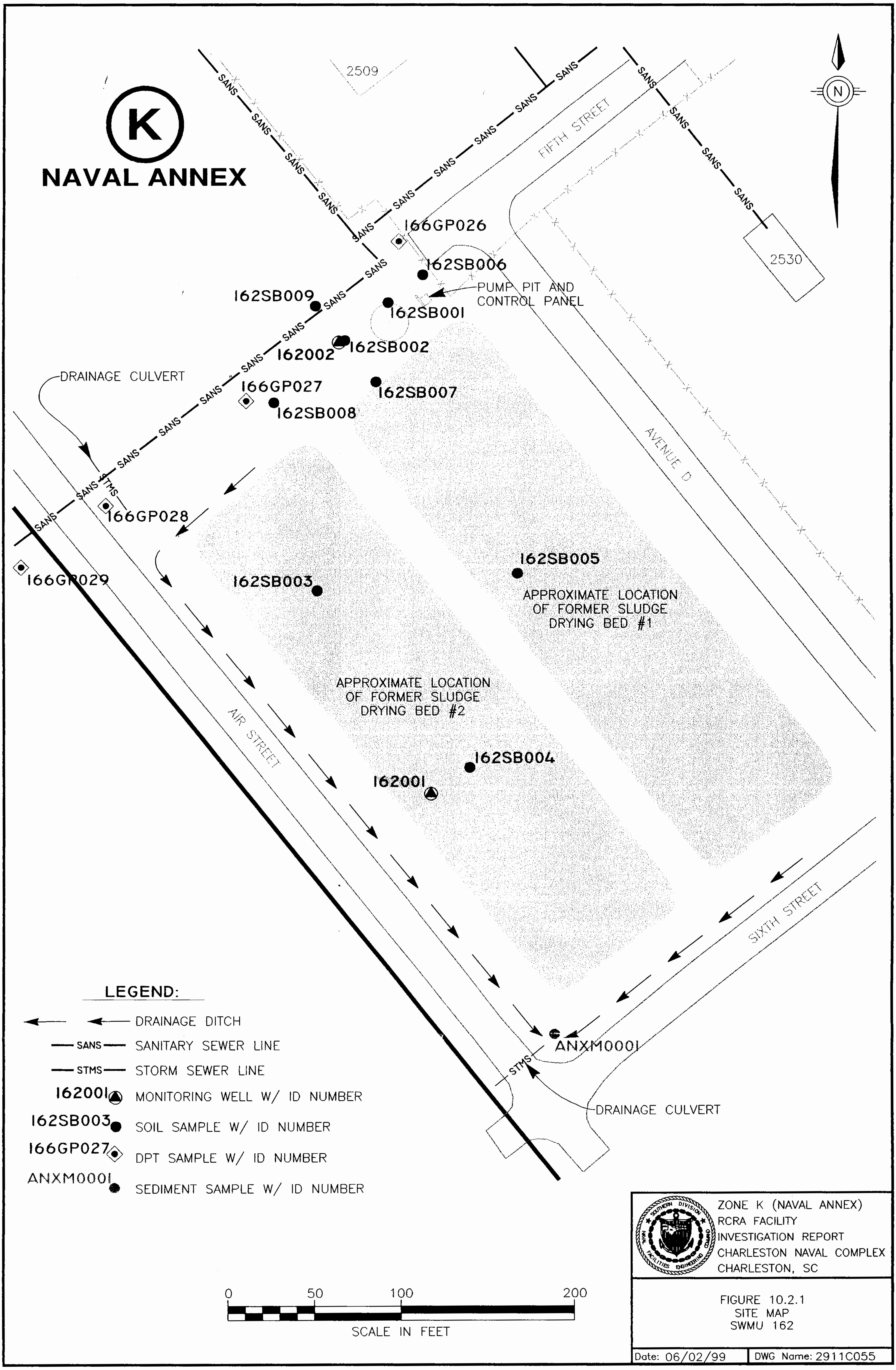
Table 10.2.1
SWMU 162
First and Second-Round Soil Sampling Summary

Sampling Round	Samples Date	Samples Collected	Sample Analyses	Comments
1	11/21/96	Upper - 5(5) Lower - 5(5) Duplicates - 2	Standard Suite Appendix IX	Four additional samples were collected for site characterization.
2	2/13/97	Upper - 4 (0)	SVOCs and metals	

Note:
() = Parentheses indicate number of samples proposed in the RFI Work Plan.
Standard Suite = VOCs, SVOCs, metals, cyanides, pesticides, and PCBs at DQO Level III,
Appendix IX = Standard Suite plus hex-chrome, dioxins, herbicides, and OP pesticides at DQO Level IV.

10.2.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.2.2. Inorganic analytical results are summarized in Table 10.2.3. Table 10.2.4 summarizes all analytes detected in soil at SWMU 162. Concentrations are listed in bold type if they exceeded their respective screening concentrations (the applicable residential soil RBC or SSL and, when available, the associated background concentration). Appendix F is a complete analytical data report for all samples collected in Zone K, including SWMU 162.



K
NAVAL ANNEX
2509
2530
FIFTH STREET
AVENUE D
AIR STREET
SIXTH STREET
SANS
STMS
166GP026
162SB006
PUMP PIT AND CONTROL PANEL
162SB009
162SB001
162002
162SB002
DRAINAGE CULVERT
166GP027
162SB007
162SB008
166GP028
166GP029
162SB003
162SB005
APPROXIMATE LOCATION OF FORMER SLUDGE DRYING BED #1
APPROXIMATE LOCATION OF FORMER SLUDGE DRYING BED #2
162SB004
162001
ANXM0001
DRAINAGE CULVERT
LEGEND:
DRAINAGE DITCH
SANS SANITARY SEWER LINE
STMS STORM SEWER LINE
162001 MONITORING WELL W/ ID NUMBER
162SB003 SOIL SAMPLE W/ ID NUMBER
166GP027 DPT SAMPLE W/ ID NUMBER
ANXM0001 SEDIMENT SAMPLE W/ ID NUMBER
0 50 100 200
SCALE IN FEET
ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.2.1
SITE MAP
SWMU 162
Date: 06/02/99
DWG Name: 2911C055

Table 10.2.2
SWMU 162
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Semivolatile Organic Compounds (μg/kg)						
14 samples collected, 9 upper-interval, 5 lower-interval, and 2 duplicate samples for Appendix IX analysis.						
BEQs	Upper	3/9	190 - 581	433	87	
	Lower	0/5	ND	ND	4,000	
Benzo(a)anthracene	Upper	3/9	170 - 480	348	870	0
	Lower	0/5	ND	ND	800	0
Benzo(a)pyrene	Upper	3/9	140 - 440	330	87	3
	Lower	0/5	ND	ND	4,000	0
Benzo(b)fluoranthene	Upper	3/9	250 - 710	467	870	0
	Lower	0/5	ND	ND	2,300	0
Benzo(k)fluoranthene	Upper	2/9	240 - 420	330	8,700	0
	Lower	0/5	ND	ND	25,000	0
Chrysene	Upper	3/9	150 -510	328	87,000	0
	Lower	0/5	ND	ND	80,000	0
Indeno(1,2,3-cd)pyrene	Upper	3/9	76 -250	172	870	0
	Lower	0/5	ND	ND	7,000	0
Benzo(g,h,i) perylene	Upper	2/9	200 - 250	225	160,00	0
	Lower	0/5	ND	ND	57,000,000	0
Fluoranthene	Upper	3/9	310 -740	552	310,000	0
	Lower	0/5	ND	ND	2,100,000	0
Phenanthrene	Upper	3/9	93 - 164	136	160,00	0
	Lower	0/5	ND	ND	660,000	0
Pyrene	Upper	3/9	210 - 610	473	230,000	0
	Lower	0/5	ND	ND	2,100,000	0
Pesticides (μg/kg)						
10 samples collected, 5 upper-interval, 5 lower-interval and 2 duplicate samples for Appendix IX analysis						
4,4'-DDD	Upper	5/5	7.33 -147	86.1	2,700	0
	Lower	0/5	ND	ND	8,000	0
4,4'-DDE	Upper	5/5	30.9 - 450	273	1,900	0
	Lower	3/5	4.79 - 8.67	6.16	27,000	0
4,4'-DDT	Upper	5/5	27.9 - 600	351	1,900	0
	Lower	4/5	4.15 -10.3	8.2	16,000	0
alpha-Chlordane	Upper	5/5	5.87 - 70.1	30.5	1,800[b]	0
	Lower	1/5	2.47	2.47	5,000	0
gamma-Chlordane	Upper	5/5	21.2 - 123	63.0	1,800[b]	0
	Lower	0/5	ND	ND	5,000	0
Dieldrin	Upper	2/5	6.96 - 14.3	10.6	40	0
	Lower	0/5	ND	ND	2.0	0
Endrin aldehyde	Upper	1/5	4.24	4.24	2300[e]	0
	Lower	0/5	ND	ND	340	0
Heptachlor expoxide	Upper	3/5	2.56 - 16.8	8.35	70	0
	Lower	0/5	ND	ND	330	0

Table 10.2.2
SWMU 162
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Total Petroleum Hydrocarbons (mg/kg)						
10 samples collected, 5 upper-interval, 5 lower-interval, 2 duplicates for Appendix IX analysis.						
TPH-DRO	Upper	2/5	20.2 - 22.4	21.3	100[c]	0
	Lower	0/5	ND	ND	100[c]	NA
Dioxin (ng/kg)						
2 Samples collected, 1 upper-interval duplicate, and 1 lower-interval duplicate.						
TCDD TEQ	Upper	1/1	3.74	3.74	4.3	0
	Lower	1/1	2.7E - 02	NA	1,600	0

Notes:
[a] = RBC for Endrin was used a surrogate for Endrin Aldehyde.
[b] = RBC for chlordane was used as a surrogate for alpha-Chlordane.
[c] Charleston Naval Complex project screening level
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed

Table 10.2.3
SWMU 162
Inorganics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC & Background (upper) or SSL & Background (lower)
Inorganics (mg/kg)							
14 samples collected; 9 upper-interval, 5 lower-interval, and 2 duplicates for Appendix IX analysis							
Aluminum	Upper	9/9	5,190 -9450	7,634	11,200	7800	0
	Lower	5/5	5,940 -15,700	9,559	10,500	560,000	0
Arsenic	Upper	9/9	0.61 - 3.4	1.56	3.00	0.43[a]	1
	Lower	5/5	0.45 - 2.50	1.46	1.98	15.0	0
Barium	Upper	9/9	8.3 -19.6	12.0	25.6	550	0
	Lower	5/5	4.00 - 9.30	6.22	6.83	820	0
Beryllium	Upper	5/9	0.07 - 0.09	0.08	0.17	16.0	0
	Lower	1/5	0.12	0.12	0.12	32.0	0
Cadmium	Upper	2/9	0.09 - 0.34	0.22	0.13	3.9	0
	Lower	0/5	ND	ND	**	4.0	NA
Calcium	Upper	9/9	267 - 2,390	971	NA	NL	NA
	Lower	5/5	34 - 133	89	NA	NL	NA

Table 10.2.3
SWMU 162
Inorganics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC & Background (upper) or SSL & Background (lower)
Chromium	Upper	9/9	5 -13.2	8.89	8.4	23	0
	Lower	5/5	5.1 - 12.0	7.8	8.76	19.0	0
Cobalt	Upper	4/9	0.76 -1.1	0.87	0.34	470	0
	Lower	4/5	0.25 -0.91	0.58	0.62	990	0
Copper	Upper	9/9	1.2 - 32	7.51	3.86	310	0
	Lower	3/5	0.36 - 0.75	0.53	0.34	5,600	0
Iron	Upper	9/9	2,220 - 4,710	3,358	7,060	2,300	0
	Lower	5/5	1,700 - 7,170	3,907	5,130	NL	2
Lead	Upper	9/9	4.9 - 23.4	11.4	39.6	400[b]	0
	Lower	5/5	3.20 - 5.60	4.04	6.43	400***	0
Magnesium	Upper	9/9	132 - 337	210	NA	NL	NA
	Lower	5/5	102 - 282	222	NA	NL	NA
Manganese	Upper	9/9	5 - 15.2	8	26.4	160	0
	Lower	5/5	2.2 -8.7	6.4	5.93	480	0
Mercury	Upper	7/9	0.06 -58.2	9.9	**	2.3	2
	Lower	2/5	0.12 -0.13	0.125	**	1.0	0
Nickel	Upper	9/9	1.2 -3.6	2.2	1.70	160	0
	Lower	5/5	0.72 -4.40	2.64	2.64	65.0	0
Potassium	Upper	9/9	81.5 -203	119.4	NA	NL	NA
	Lower	5/5	66.2 -142.5	104	NA	NL	NA
Sodium	Upper	4/9	14.9 -49.7	27.9	NA	NL	NA
	Lower	0/5	ND	ND	NA	NL	NA
Tin	Upper	2/9	10.9 -11.5	11.2	19.4	4,700	0
	Lower	0/5	ND	ND	**	5,500	NA
Vanadium	Upper	9/9	6.2 -12.5	9.6	15.8	55	0
	Lower	5/5	4.75 -19.20	9.63	12.2	3,000	0
Zinc	Upper	7/9	20.4 -442	86.9	14.8	2,300	0
	Lower	0/5	ND	ND	**	6,200	NA

Notes:
a - RBC for arsenic as a carcinogen
b - RBC not available for lead. USEPA residential soil cleanup level used for comparison (OSWER Directive 9355.4-12)
NA - Not applicable/not available/not analyzed
NL - Not listed
ND - Not detected/not determined
** - Number of nondetects prevented determination of background reference concentrations.
*** - SSL value not based on target leachate concentration

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Semivolatile Organic Compounds (μg/kg)							
BEQs	162SB001	190	87	NA	ND	4,000	NA
	162SB002	581			ND		
	162SB003	528			ND		
Benzo(a)anthracene	162SB001	170	870	NA	ND	800	NA
	162SB002	480			ND		
	162SB003	395			ND		
Benzo(a)pyrene	162SB001	140	87	NA	ND	4,000	NA
	162SB002	440			ND		
	162SB003	410			ND		
Benzo(b)fluoranthene	162SB001	250	870	NA	ND	2,300	NA
	162SB002	710			ND		
	162SB003	440			ND		
Benzo(k)fluoranthene	162SB002	240	8,700	NA	ND	25,000	NA
	162SB003	420			ND		
Chrysene	162SB001	150	87,000	NA	ND	80,000	NA
	162SB002	510			ND		
	162SB003	325			ND		
Indeno(1,2,3-cd)pyrene	162SB001	76	870	NA	ND	7,000	NA
	162SB002	190			ND		
	162SB003	250			ND		
Benzo(g,h,i)perylene	162SB002	200	160,000	NA	ND	57,000,000	NA
	162SB003	250			ND		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Fluoranthene	162SB001	310	310,000	NA	ND	2,100,000	NA
	162SB002	740			ND		
	162SB003	605			ND		
Phenanthrene	162SB001	93	160,000	NA	ND	660,000	NA
	162SB002	150			ND		
	162SB003	163.5			ND		
Pyrene	162SB001	210	230,000	NA	ND	2,100,000	NA
	162SB002	600			ND		
	162SB003	610			ND		
Pesticides/PCBs (μg/kg)							
4,4-DDD	162SB001	104	2,700	NA	ND	8,000	NA
	162SB002	91.8			ND		
	162SB003	80.3			ND		
	162SB004	7.33			ND		
	162SB005	147			ND		
4,4-DDE	162SB001	390	1,900	NA	5.01	27,000	NA
	162SB002	336			ND		
	162SB003	159			8.67		
	162SB004	30.9			ND		
	162SB005	450			4.785		
4,4-DDT	162SB001	596	1,900	NA	10.3	16,000	NA
	162SB002	383			ND		
	162SB003	148.5			10.1		
	162SB004	27.9			4.15		
	162SB005	600			8.07		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
alpha-Chlordane	162SB001	18.5	1,800	NA	ND	5,000	NA
	162SB002	17.4			ND		
	162SB003	40.7			2.47		
	162SB004	5.87			ND		
	162SB005	70.1			ND		
Dieldrin	162SB002	14.3	40	NA	ND	2.0	NA
	162SB003	6.96		NA	ND		
Endrin aldehyde	162SB005	4.24	2,300	NA	ND	340	NA
gamma-Chlordane	162SB001	78.2	1,800	NA	ND	5,000	NA
	162SB002	23.9			ND		
	162SB003	68.55			ND		
	162SB004	21.2			ND		
	162SB005	123			ND		
Heptachlor epoxide	162SB001	16.8	70	NA	ND	330	NA
	162SB003	2.555			ND		
	162SB005	5.68			ND		
Dioxin Compounds (ng/kg)							
TCDD TEQ	162SB003	3.74	4.3	NA	ND	1,600	NA
	162SB005	ND			0.03		
1234678-HpCDD	162SB003	104	430	NA	ND	110,000	NA
1234678-HpCDF	162SB003	21.6	430	NA	ND	54,000	NA
1234789-HpCDF	162SB003	2.22	430	NA	ND	54,000	NA
123478-HxCDD	162SB003	2.11	43	NA	ND	4,100	NA

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
123478-HxCDF	162SB003	8.13	43	NA	ND	220,000	NA
123678-HxCDD	162SB003	4.55	43	NA	ND	4,100	NA
123789-HxCDD	162SB003	1.38	43	NA	ND	4,100	NA
OCDD	162SB003	813	4,300	NA	ND	1,100,000	NA
	162SB005	ND			26.6		
OCDF	162SB003	35	4,300	NA	ND	540,000	NA
TPH-DRO (mg/kg)							
Diesel	162SB001	20.2	100	NA	ND	100	NA
	162SB002	22.4			ND		
NITRATE							
Nitrate (as N)	162SB002	1.5			1.4		
	162SB003	1.3			ND		
	162SB004	0.66			0.88		
	162SB005	2.3			0.78		
SULFIDE							
Sulfide	162SB001	.55			0.59		
	162SB002	.55			0.6		
	162SB003	.56			0.62		
	162SB004	.55			0.63		
	162SB005	.58			0.65		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Inorganics (mg/kg)							
Aluminum (Al)	162SB001	8,590	7800	11200	15,700	560,000	10500
	162SB002	5,190			5,940		
	162SB003	8,185			8,350		
	162SB004	6,930			9,210		
	162SB005	7,940			8,595		
	162SB006	8,160			NT		
	162SB007	9,450			NT		
	162SB008	7,350			NT		
	162SB009	6,910			NT		
Arsenic (As)	162SB001	1.8	0.43[a]	3	2.4	15	1.98
	162SB002	1.4			0.45		
	162SB003	1.35			2.5		
	162SB004	1.5			0.98		
	162SB005	1.4			0.965		
	162SB006	1.2			NT		
	162SB007	1.4			NT		
	162SB008	0.61			NT		
	162SB009	3.4			NT		
Barium (Ba)	162SB001	12.4	550	25.6	9.3	820	6.83
	162SB002	19.6			5.2		
	162SB003	12.35			6.9		
	162SB004	8.4			4		
	162SB005	14.2			5.7		
	162SB006	9.8			NT		
	162SB007	14.3			NT		
	162SB008	8.3			NT		
	162SB009	8.9			NT		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Beryllium (Be)	162SB003	0.09	16	0.17	ND	32	0.12
	162SB005	ND			0.12		
	162SB006	0.07			NT		
	162SB007	0.08			NT		
	162SB008	0.09			NT		
	162SB009	0.09			NT		
Cadmium (Cd)	162SB002	0.34	3.9	0.13	ND	4	NA
	162SB003	0.09			ND		
Calcium (Ca)	162SB001	981	NL	NA	67	NL	NA
	162SB002	1,050			34		
	162SB003	877			133		
	162SB004	533			83.1		
	162SB005	2,390			127		
	162SB006	1,920			NT		
	162SB007	304			NT		
	162SB008	267			NT		
	162SB009	420			NT		
Chromium (Cr)	162SB001	10.3	23	8.4	12	19	8.76
	162SB002	13.2			5.1		
	162SB003	10.6			7.5		
	162SB004	6.4			8.3		
	162SB005	9.8			6		
	162SB006	8.9			NT		
	162SB007	9.9			NT		
	162SB008	5.9			NT		
	162SB009	5			NT		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Cobalt (Co)	162SB001	ND	470	0.34	0.25	990	0.62
	162SB003	ND			0.91		
	162SB004	ND			0.41		
	162SB005	ND			0.75		
	162SB006	1.1			NT		
	162SB007	0.76			NT		
	162SB008	0.82			NT		
	162SB009	0.81			NT		
Copper (Cu)	162SB001	6.9	310	3.86	ND	5,600	0.34
	162SB002	32			ND		
	162SB003	7.9			0.48		
	162SB004	1.8			0.75		
	162SB005	5.8			0.36		
	162SB006	7.5			NT		
	162SB007	2.9			NT		
	162SB008	1.6			NT		
	162SB009	1.2			NT		
Iron (Fe)	162SB001	3,990	2300	7060	7,170	NL	5130
	162SB002	2,960			2,080		
	162SB003	3,675			5,610		
	162SB004	3,530			1,700		
	162SB005	3,020			2,975		
	162SB006	3,580			NT		
	162SB007	4,710			NT		
	162SB008	2,540			NT		
	162SB009	2,220			NT		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Lead (Pb)	162SB001	12.9	400[a]	39.6	5.6	400[a]	6.43
	162SB002	23.4			3.3		
	162SB003	12.4			4.2		
	162SB004	9.2			3.9		
	162SB005	16.5			3.2		
	162SB006	6.9			NT		
	162SB007	11.2			NT		
	162SB008	4.9			NT		
	162SB009	5.1			NT		
Magnesium (Mg)	162SB001	220	NL	NA	282	NL	NA
	162SB002	172			182		
	162SB003	177.5			263		
	162SB004	132			102		
	162SB005	197			280		
	162SB006	337			NT		
	162SB007	211			NT		
	162SB008	239			NT		
	162SB009	208			NT		
Manganese (Mn)	162SB001	7.3	160	26.4	8.3	480	5.93
	162SB002	9.3			4.8		
	162SB003	6.4			8.7		
	162SB004	5			2.2		
	162SB005	9.3			8.05		
	162SB006	15.2			NT		
	162SB007	6.1			NT		
	162SB008	7.4			NT		
	162SB009	5.9			NT		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Mercury (Hg)	162SB001	10.3	2.3	NA	0.12	1	NA
	162SB002	58.2			0.13		
	162SB003	0.155			ND		
	162SB004	0.09			ND		
	162SB005	0.08			ND		
	162SB006	0.4			NT		
	162SB008	0.06			NT		
Nickel (Ni)	162SB001	2.4	160	1.7	3.3	65	2.64
	162SB002	1.2			0.72		
	162SB003	2.2			2.9		
	162SB004	1.9			4.4		
	162SB005	2			1.9		
	162SB006	3.6			NT		
	162SB007	3			NT		
	162SB008	2			NT		
	162SB009	1.9			NT		
Potassium (K)	162SB001	113	NL	NA	129	NL	NA
	162SB002	203			66.2		
	162SB003	88.8			115		
	162SB004	95.1			66.4		
	162SB005	107			142.5		
	162SB006	148			NT		
	162SB007	81.5			NT		
	162SB008	115			NT		
	162SB009	123			NT		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Sodium (Na)	162SB006	49.7	NL	NA	NT	NL	NA
	162SB007	26.4			NT		
	162SB008	14.9			NT		
	162SB009	20.7			NT		
Tin (Sn)	162SB002	11.5	4,700	19.4	ND	5,500	NA
	162SB006	10.9			NT		
Vanadium (V)	162SB001	12.5	55	15.8	19.2	3,000	12.2
	162SB002	6.2			7.5		
	162SB003	11.65			11.6		
	162SB004	10.6			5.1		
	162SB005	9.8			4.75		
	162SB006	9.4			NT		
	162SB007	11.9			NT		
	162SB008	7.6			NT		
	162SB009	6.7			NT		

Table 10.2.4
SWMU 162
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Zinc (Zn)	162SB001	22.6	2,300	14.8	ND	6,200	NA
	162SB002	25.8			ND		
	162SB003	30.8			ND		
	162SB005	20.4			ND		
	162SB006	26.6			NT		
	162SB007	40.4			NT		
	162SB009	442			NT		

Notes:

a = RBC not available for lead, USEPA residential soil cleanup level used for comparision (OSWER Directive 9355.4-12).
* = Residential RBCs (THQ=0.1) were used as a reference concentration for upper-interval samples. Generic soil-to groundwater SSLs (DAF=10) from *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as a reference concentration for lower-interval samples.

Bold concentrations exceed the RBCs, SSL, and the zone background.
All background values for Zone K are based on twice the means of the grid sample concentrations.

DAF = Diluation attenuation factor
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NT = Not taken
RBC = Risk-based concentration
SSL = Soil screening level
THQ = Target hazard quotient
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
ng/kg = Nanograms per kilogram
** = Number of nondetects prevented determination of background concentration.

Volatile Organic Compounds in Soil

No VOCs were detected in soil at SWMU 162.

Semivolatile Organic Compounds in Soil

During the first round of soil sampling, 10 SVOCs were detected in the upper-interval while none were detected in the lower sample interval. All the SVOCs were detected in the three upper-interval samples (162SB001, 002, and 003). Two of these sample locations (162SB001 and 002) are near the former sewage treatment facility. Sample location 162SB003 is in the sludge disposal area.

Benzo(a)pyrene [B(a)P] was the only SVOC to exceed a screening concentration. B(a)P exceeded its 87 μg/kg RBC in each of the three samples that contained positive detections.

The BEQs computed for each of the three samples exceeded B(a)P's RBC: 162SB001, 190 μg/kg; 162SB002, 581 μg/kg, and 162SB003, 196 μg/kg. Seventy-five percent of each of the BEQs was attributable to the B(a)P concentration in each sample. Figure 10.2.2 shows BEQ values calculated for surface soil sample locations.

During the second round of soil sampling, four surface soil samples (162SB006, 007, 008, and 009) were collected around the 162SB001 and 002 sample locations. No SVOCs were detected in these samples.

Pesticides/PCBs in Soil

Eight pesticides were detected in soil samples at SWMU 162, primarily in the upper-interval sample. However, two pesticides, DDE and DDT, were also detected in lower-interval samples. Each first-round sample, except for 162SB00202, contained at least one pesticide detection. All pesticide detections were below their RBCs or SSL screening concentrations.

Other Organic Compounds in Soil

TPH-DRO was detected in two of five first-round, upper-interval soil samples. Each TPH-DRO concentration was below the CNC TPH 100 mg/kg screening concentration.

Dioxin was detected in the two duplicate soil samples. The TCDD TEQ for each sample was below the CNC 4.3 ng/kg screening concentration.

No other organic compounds were detected in SWMU 162 soil samples.

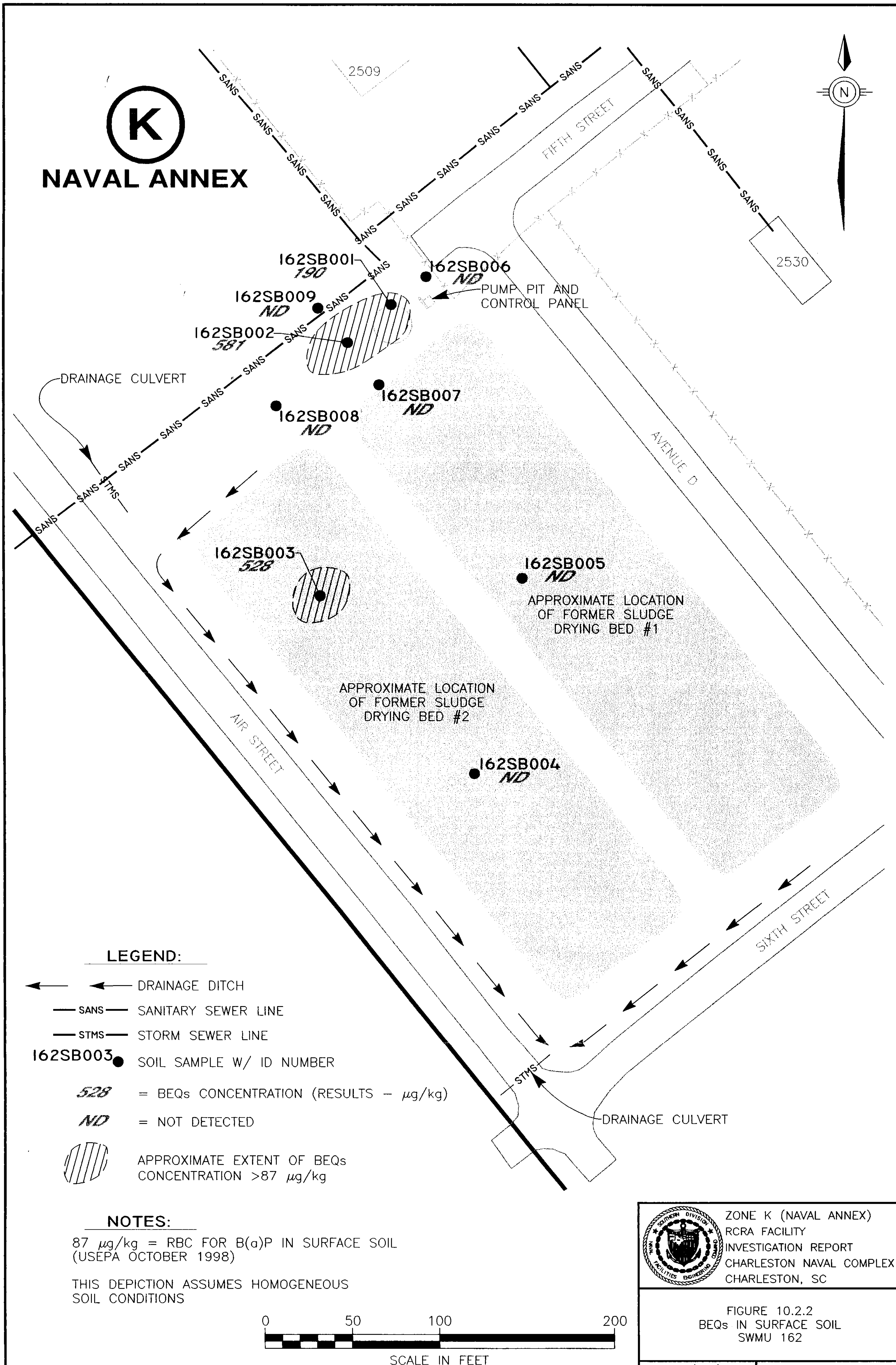
Inorganics in Soil

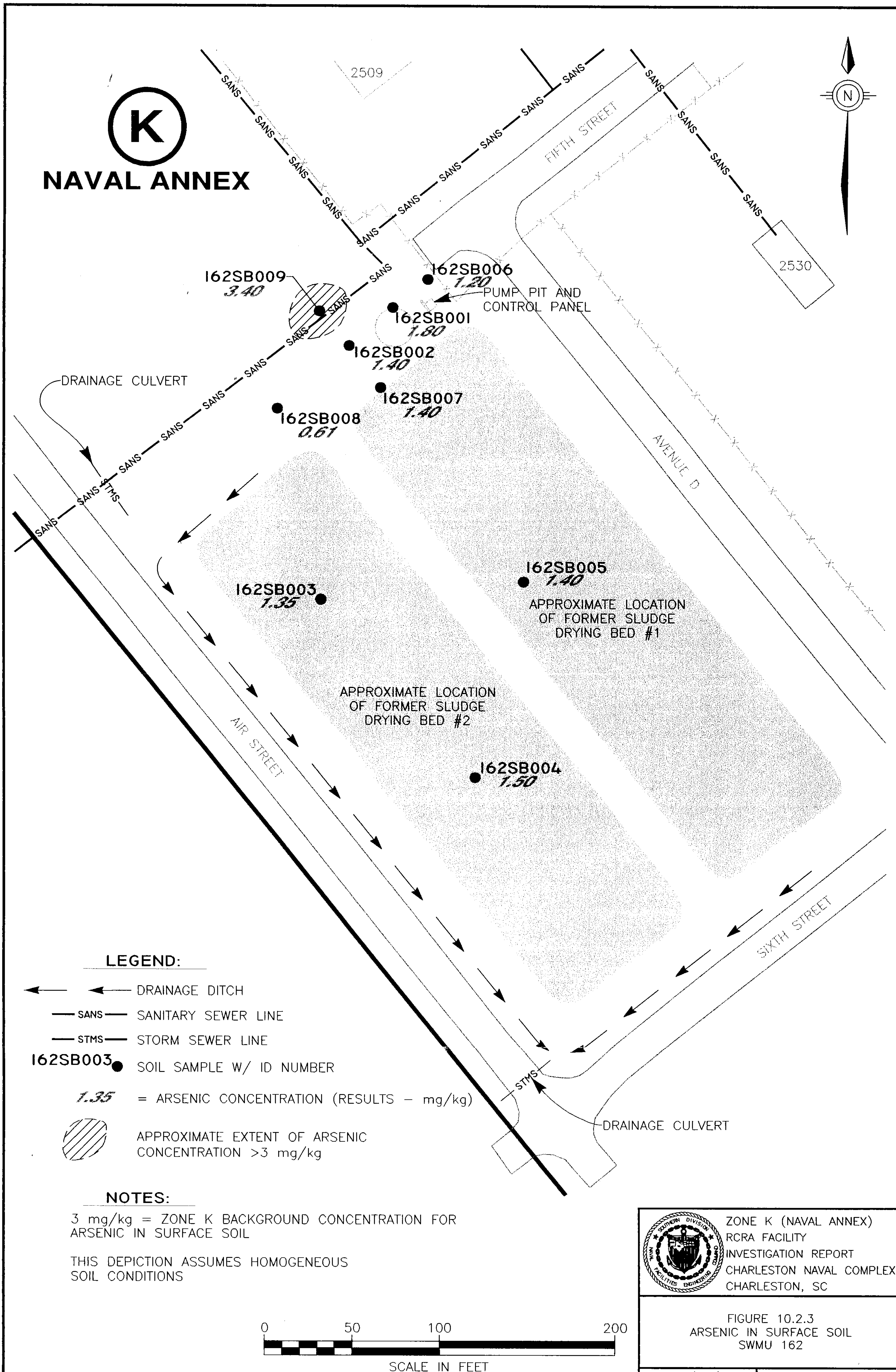
Mercury and arsenic were the only two inorganics in SWMU 162 surface soil that exceeded their screening concentrations. Arsenic exceeded both its RBC and background concentrations at 162SB00901. Mercury, which exceeded its RBC at 162SB00101 and 162SB00201, had no background concentration at Zone K due to a lack of detections in the background data set. Figures 10.2.3 and 10.2.4 show arsenic and mercury concentrations detected in surface soil.

The following exceeded their subsurface background concentrations in the lower-interval: aluminum, arsenic, barium, chromium, cobalt, copper, manganese, mercury, nickel, and vanadium. However, no lower-level detection exceeded its SSL, except for iron, which has no reported SSL.

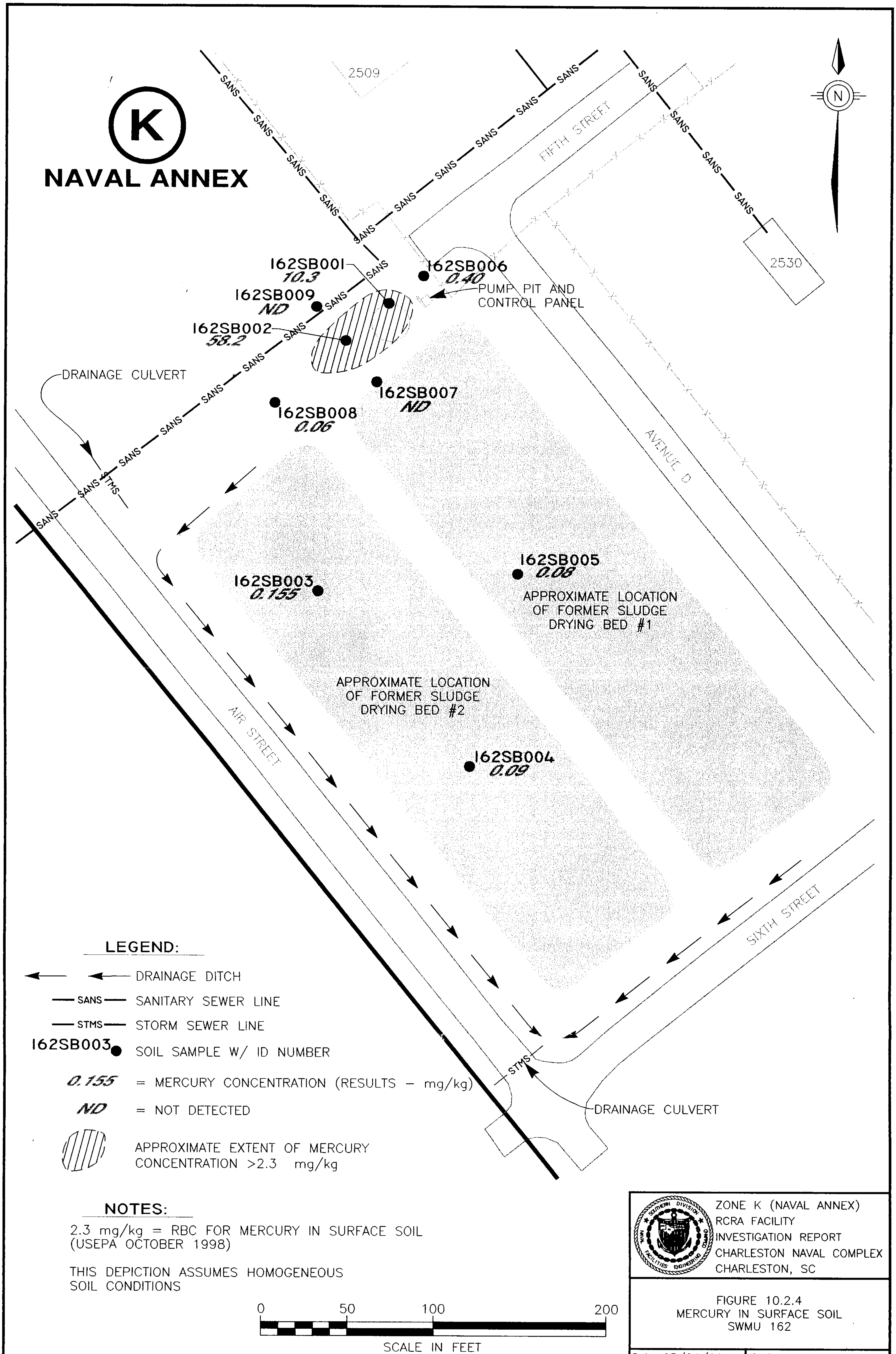
10.2.3 Groundwater Sampling and Analysis

The final RFI work plan proposed the installation of two shallow monitoring wells for SWMU 162. One of the wells (NBCK162001) is near the former sewage treatment facility and the other (NBCK162002) is near the sludge dewatering pits. Both well locations are shown on Figure 10.2.1.


K
NAVAL ANNEX
2509
2530
FIFTH STREET
AVENUE D
AIR STREET
SIXTH STREET
SANS
STMS
162SB001
190
162SB009
ND
162SB002
581
162SB006
ND
PUMP PIT AND
CONTROL PANEL
DRAINAGE CULVERT
162SB007
ND
162SB008
ND
162SB003
528
162SB005
ND
APPROXIMATE LOCATION
OF FORMER SLUDGE
DRYING BED #1
APPROXIMATE LOCATION
OF FORMER SLUDGE
DRYING BED #2
162SB004
ND
DRAINAGE CULVERT
LEGEND:
DRAINAGE DITCH
SANS SANITARY SEWER LINE
STMS STORM SEWER LINE
162SB003 SOIL SAMPLE W/ ID NUMBER
528 = BEQs CONCENTRATION (RESULTS – μg/kg)
ND = NOT DETECTED
APPROXIMATE EXTENT OF BEQs
CONCENTRATION >87 μg/kg
NOTES:
87 μg/kg = RBC FOR B(a)P IN SURFACE SOIL
(USEPA OCTOBER 1998)
THIS DEPICTION ASSUMES HOMOGENEOUS
SOIL CONDITIONS
0
50
100
200
SCALE IN FEET
ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.2.2
BEQs IN SURFACE SOIL
SWMU 162
Date: 05/21/99
DWG Name: 2911C070



K
NAVAL ANNEX
2509
2530
SANS
STMS
FIFTH STREET
AVENUE D
AIR STREET
SIXTH STREET
162SB009 3.40
162SB006 1.20
PUMP PIT AND CONTROL PANEL
162SB001 1.80
162SB002 1.40
162SB007 1.40
162SB008 0.61
DRAINAGE CULVERT
162SB003 1.35
162SB005 1.40
APPROXIMATE LOCATION OF FORMER SLUDGE DRYING BED #1
APPROXIMATE LOCATION OF FORMER SLUDGE DRYING BED #2
162SB004 1.50
DRAINAGE CULVERT
N
LEGEND:
DRAINAGE DITCH
SANS — SANITARY SEWER LINE
STMS — STORM SEWER LINE
162SB003 SOIL SAMPLE W/ ID NUMBER
1.35 = ARSENIC CONCENTRATION (RESULTS – mg/kg)
APPROXIMATE EXTENT OF ARSENIC CONCENTRATION >3 mg/kg
NOTES:
3 mg/kg = ZONE K BACKGROUND CONCENTRATION FOR ARSENIC IN SURFACE SOIL
THIS DEPICTION ASSUMES HOMOGENEOUS SOIL CONDITIONS
0 50 100 200
SCALE IN FEET
ZONE K (NAVAL ANNEX)
RCRA FACILITY INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.2.3
ARSENIC IN SURFACE SOIL
SWMU 162
Date: 05/21/99
DWG Name: 2911C071


K
NAVAL ANNEX
N
2509
2530
FIFTH STREET
AVENUE D
AIR STREET
SIXTH STREET
SANS
STMS
162SB001
10.3
162SB009
ND
162SB002
58.2
162SB006
0.40
PUMP PIT AND
CONTROL PANEL
DRAINAGE CULVERT
162SB007
ND
162SB008
0.06
162SB005
0.08
APPROXIMATE LOCATION
OF FORMER SLUDGE
DRYING BED #1
162SB003
0.155
APPROXIMATE LOCATION
OF FORMER SLUDGE
DRYING BED #2
162SB004
0.09
DRAINAGE CULVERT
LEGEND:
DRAINAGE DITCH
SANS SANITARY SEWER LINE
STMS STORM SEWER LINE
162SB003 SOIL SAMPLE W/ ID NUMBER
0.155 = MERCURY CONCENTRATION (RESULTS – mg/kg)
ND = NOT DETECTED
APPROXIMATE EXTENT OF MERCURY
CONCENTRATION >2.3 mg/kg
NOTES:
2.3 mg/kg = RBC FOR MERCURY IN SURFACE SOIL
(USEPA OCTOBER 1998)
THIS DEPICTION ASSUMES HOMOGENEOUS
SOIL CONDITIONS
0
50
100
200
SCALE IN FEET
ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.2.4
MERCURY IN SURFACE SOIL
SWMU 162
Date: 05/24/99
DWG Name: 2911C072

After installation and development of the two wells, the first-round RFI samples were collected and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and TPH at DQO Level III.

Second-round SWMU 162 groundwater samples were also analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and TPH at DQO Level III. Second-round samples were collected by the CEERD in April 1997. Third and fourth-round samples were collected in July and October 1997, respectively, and analyzed for VOCs, SVOCs, metals, pesticides, and PCBs at DQO Level III. Table 10.2.5 summarizes groundwater sampling at SWMU 162.

Table 10.2.5
SWMU 162
Groundwater Sampling Summary

Sampling Round	Sampling Date	Wells Sampled	Sample Analyses	Comments
1	1/6/97 ½/97	162GW00101 162GW00201	Standard Suite and TPH	None
2	4/17/97 4/17/97	162GW00102 162GW00202	Standard Suite and TPH	None
3	7/24/97 7/24/97	162GW00103 162GW00203	Standard Suite	None
4	10/20/97 10/20/97	162GW00104 162GW00104	Standard Suite	None

Note:
Standard Suite = VOCs, SVOCs, metals, cyanide, pesticides and PCBs,

The shallow monitoring wells were installed at 15 feet bgs in the water table aquifer, as described in Section 3.3 of this report.

10.2.4 Nature and Extent of Contamination in Groundwater

Table 10.2.6 summarizes groundwater inorganic analytical results for SWMU 162. Table 10.2.7 summarizes all analytes detected in shallow groundwater at SWMU 162. Appendix F is a complete analytical data report for all samples collected in Zone K, including those collected at SWMU 162.

Table 10.2.6
SWMU 162
Inorganics Detected In Groundwater

Parameter	Sample Round	Detection Frequency	Detection Range	Mean	Shallow Groundwater Background	Tap-water RBC/MCL	Number of Samples Exceeding Lower of RBC or MCL Background
Inorganics (μg/L) (Two shallow groundwater samples were collected during each event.)							
Aluminum	First	½	369	369	471	3,700/50	0
	Second	0/2	ND	ND			0
	Third	½	881	881			1
	Fourth	½	689	689			1
Barium	First	2/2	9.5 - 21.3	15.4	31.2	260/2,000	0
	Second	½	8.2	8.2			0
	Third	2/2	9.10 - 27.2	18.15			0
	Fourth	2/2	8.10 - 29.0	18.55			0
Calcium	First	2/2	4,810 - 5,510	5,160	NA	NL / NL	NA
	Second	2/2	5,480 - 7,100	6,290			NA
	Third	2/2	4,770 - 6,040	5,405			NA
	Fourth	2/2	6,040 - 6,080	6,060			NA
Copper	First	0/2	ND	ND	2.81	150/1,000	0
	Second	½	8.9	8.9			0
	Third	½	3.30	3.3			0
	Fourth	0/2	ND	ND			0
Iron	First	2/2	608 - 613	611	235	1,100/300	2
	Second	2/2	1,110 - 1,240	1,175			2
	Third	2/2	601 - 1,410	1,006			2
	Fourth	2/2	599 - 1,620	1,110			2
Lead	First	0/2	ND	ND	1.94	NL/15	0
	Second	0/2	ND	ND			0
	Third	½	1.80	1.80			0
	Fourth	0/2	ND	ND			0
Magnesium	First	2/2	695 - 903	799	NA	NL/NL	NA
	Second	2/2	685 - 1,040	863			NA
	Third	2/2	632 - 1,170	901			NA
	Fourth	2/2	569 - 1,300	935			NA
Manganese	First	2/2	24.8 - 30.8	27.8	9.33	73/50	0
	Second	2/2	15.1 - 21.6	18.4			0
	Third	2/2	13.0 - 16.9	14.95			0
	Fourth	2/2	14.0 - 17.5	15.75			0
Potassium	First	2/2	1,050 - 1,400	1,225	NA	NL/NL	NA
	Second	2/2	1,010 - 1,400	1,205			NA
	Third	2/2	1,090 - 1,240	1,165			NA
	Fourth	2/2	1,310 - 1,490	1,400			NA

Table 10.2.6
SWMU 162
Inorganics Detected In Groundwater

Parameter	Sample Round	Detection Frequency	Detection Range	Mean	Shallow Groundwater Background	Tap-water RBC/MCL	Number of Samples Exceeding Lower of RBC or MCL Background
Inorganics (μg/L) (Two shallow groundwater samples were collected during each event.)							
Silver	First	½	12.1	12.1	NA	18/100	0
	Second	0/2	ND	ND			0
	Third	0/2	ND	ND			0
	Fourth	0/2	ND	ND			0
Sodium	First	2/2	2,100 - 2,320	2,210	NA	NL/NL	NA
	Second	0/2	ND	ND			NA
	Third	2/2	3,950 - 4,100	4,025			NA
	Fourth	0/2	ND	ND			NA
Vanadium	First	0/2	ND	ND	0.80	26/NL	0
	Second	0/2	ND	ND			0
	Third	½	0.92	0.92			0
	Fourth	0/2	ND	ND			0
Zinc	First	0/2	ND	ND	NA	1,100/5,000	0
	Second	0/2	ND	ND			0
	Third	2/2	24.6 - 26.1	25.35			0
	Fourth	0/2	ND	ND			0

Notes:

**	=	Number of nondetects prevented determination of background concentration.
NA	=	Not applicable/not available
ND	=	Not detected/not determined
NL	=	Not listed
μg/L	=	Micrograms per liter

Table 10.2.7
SWMU 162
Analytes Detected in Shallow Groundwater

Parameter	Location	1st Round	2nd Round	3rd Round	4th Round	Tap-water RBC*	MCL/ SMCL*	Shallow Background
Inorganics (μg/L)								
Aluminum (Al)	162001	369	ND	**881**	**689**	3,700	50	471
	162002	ND	ND	ND	ND			
Barium (Ba)	162001	21.3	ND	27.2	29.0	260	2,000	31.2
	162002	9.50	8.20	9.10	8.10			
Calcium (Ca)	162001	5,510	7,100	6,040	6,040	NL	NL	NA
	162002	4,810	5,480	4,770	6,080			

Table 10.2.7
SWMU 162
Analytes Detected in Shallow Groundwater

Parameter	Location	1st Round	2nd Round	3rd Round	4th Round	Tap-water RBC*	MCL/ SMCL*	Shallow Background
Copper (Cu)	162001	ND	ND	ND	ND	150	1,000	2.81
	162002	ND	8.90	3.30	ND			
Iron (Fe)	162001	608	1,110	1,410	1,620	1,100	300	235
	162002	613	1,240	601	599			
Lead (Pb)	162001	ND	ND	1.80	ND	NL	15	1.94
	162002	ND	ND	ND	ND			
Magnesium (Mg)	162001	695	685	632	569	NL	NL	NA
	162002	903	1,040	1,170	1,300			
Manganese (Mn)	162001	30.8	21.6	16.9	17.5	73	50	9.33
	162002	24.8	15.1	13.0	14.0			
Potassium (K)	162001	1,400	1,400	1,240	1,490	NL	NL	NA
	162002	1,050	1,010	1,090	1,310			
Silver (Ag)	162001	12.1	ND	ND	ND	18	100	NA
	162002	ND	ND	ND	ND			
Sodium (Na)	162001	2,100	ND	4,100	ND	NL	NL	0.80
	162002	2,320	ND	3,950	ND			
Vanadium (V)	162001	ND	ND	0.92	ND	26	NL	**
	162002	ND	ND	ND	ND			
Zinc (Zn)	162001	ND	ND	26.1	ND	1,100	5,000	NA
	162002	ND	ND	24.6	ND			

Notes:
* = Tap-water RBCs (THQ=0.1) from *Risk-Based Concentration Table* (USEPA, October 1998), and MCLs/SMCLs from *Drinking Water Regulations and Health Advisories* (USEPA, 1996e).
Bold concentrations exceed the RBC, and the zone background.
All background values for Zone K are based on twice the means of the grid sample concentrations.
μg/L = Micrograms per liter
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
** = Number of nondetects prevented determination of background concentration.

Organics in Groundwater

No organic compounds were detected in SWMU 162 groundwater samples.

Inorganics in Groundwater

Several inorganics were detected in each of the four rounds of SWMU 162 groundwater samples. Aluminum exceeded its respective SMCL and shallow background concentrations during rounds three and four, with detections ranging from 369 to 881 μg/L. Additionally, iron exceeded its SMCL and background concentration during all four rounds and its RBC during rounds two through four. Detected iron concentrations ranged from 599 to 1620 μg/L. Figures 10.2.5 and 10.2.6 show aluminum and iron concentrations detected in shallow groundwater, respectively.

10.2.5 Fate and Transport Assessment for SWMU 162

Environmental media sampled as part of the SWMU 162 RFI are surface soil, subsurface soil, and shallow groundwater. Potential constituent migration pathways investigated for SWMU 162 are soil to groundwater, groundwater-to-surface-water, and emission of volatiles from surface soil-to-air.

10.2.5.1 SWMU 162 — Soil to Groundwater Cross-media Transport

Tables 10.2.8 and 10.2.9 compare maximum detected organic and inorganic constituent concentrations in surface soil and subsurface soil samples to risk-based soil screening levels considered protective of groundwater. To provide a conservative screen, generic soil screening levels are used; leachate entering the aquifer is assumed to be diluted by a ratio of 10:1, with no attenuation of constituents in soil (DAF=10).

Only one organic compound — dieldrin — exceeded its groundwater protection SSL in SWMU 162 soil. This compound was detected at only two of five surface soil locations (14.3 μg/kg at 162SB002 and 6.96 μg/kg at 162SB003). The compound was not detected in subsurface soil at the same or any other locations, nor was it detected in groundwater at the Naval Annex.

Only one inorganic — mercury — exceeded its groundwater protection SSL in soil. Although mercury was detected in seven of nine surface soil samples and two of five subsurface samples, screening-level exceedances were limited to surface soil at two locations: 162SB001 (10.3 μg/kg) and 162SB002 (58.2 μg/kg). No exceedances were reported in lower-interval soil samples from any locations. Mercury was not detected in groundwater samples collected at SWMU 162.

10.2.5.2 SWMU 162 — Groundwater-to-Surface-Water Cross-Media Transport

Tables 10.2.8 and 10.2.9 also compare maximum detected organic and inorganic concentrations in shallow groundwater samples to risk-based concentrations for drinking water. To provide a conservative screen, no attenuation or dilution of constituents in groundwater is assumed before comparison to the relevant standards.

No organics or inorganics were detected in SWMU 162 groundwater at concentrations exceeding risk-based drinking water concentrations. As a result, the groundwater-to-surface-water migration pathway is not expected to be significant at SWMU 162.

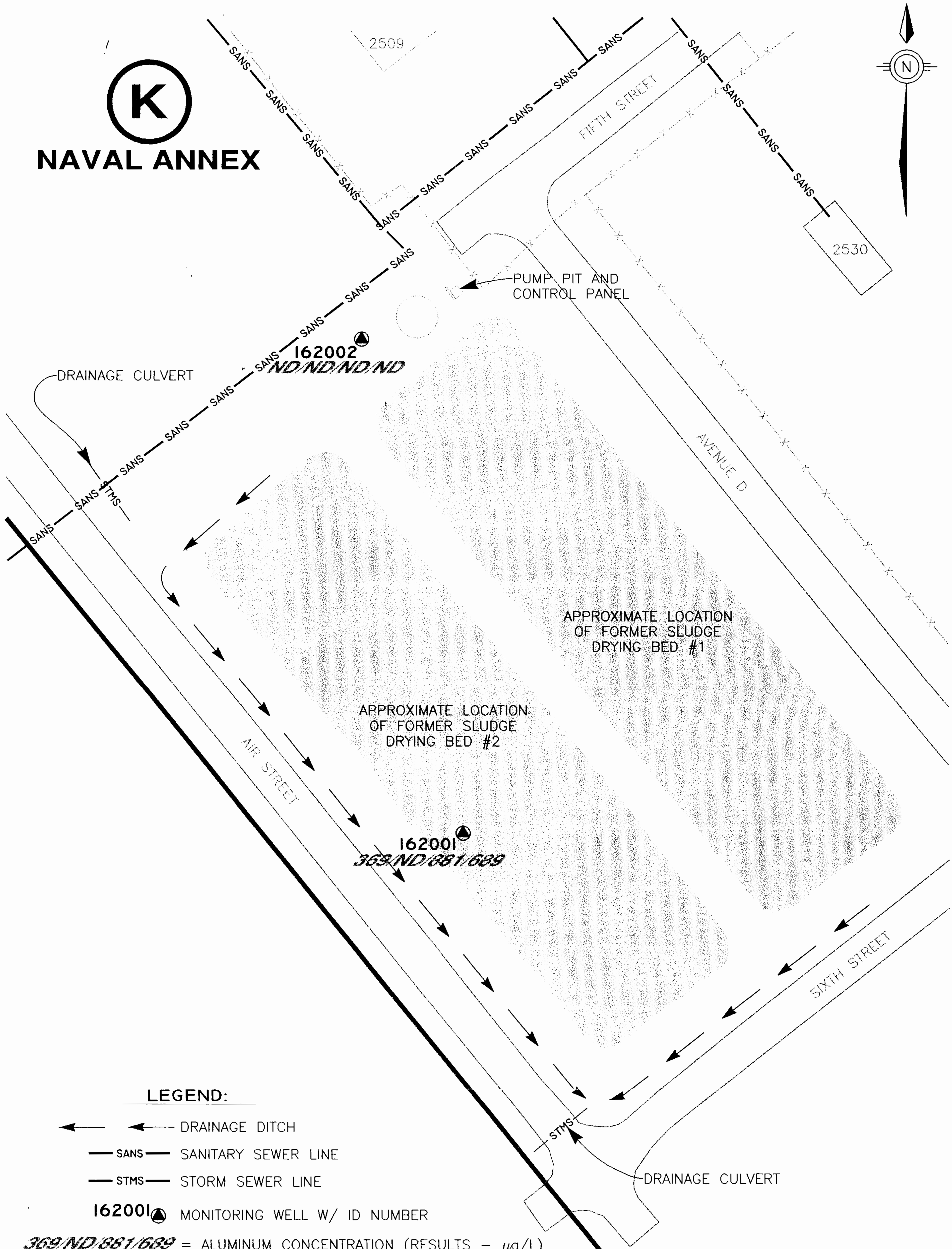
10.2.5.3 SWMU 162— Soil-to-Air Cross-media Transport

No VOCs were detected in surface soil samples at SWMU 162. However, mercury exceeded its fugitive particulate inhalation screening value at two locations. As a result, the soil-to-air migration pathway is considered valid at SWMU 162.

10.2.5.4 SWMU 162 — Fate and Transport Summary

Dieldrin and mercury exceeded their groundwater protection screening levels. However, they are not recommended for further fate and transport assessment because the exceedances were few and isolated in surface soil, absent in subsurface soil, and because neither chemical was present in groundwater.

Mercury exceeded its soil-to-air SSL in surface soil, resulting in some concern for this pathway. The pathway should be considered valid; however, its infrequent and spatially segregated exceedances suggest that the pathway is not significant.



LEGEND:

DRAINAGE DITCH

SANS — SANITARY SEWER LINE

STMS — STORM SEWER LINE

162001 MONITORING WELL W/ ID NUMBER

369/ND/881/689 = ALUMINUM CONCENTRATION (RESULTS – μg/L)
1st RND/2nd RND/3rd RND/4th RND

ND = NOT DETECTED

NOTE:

471μ g/L = ZONE K BACKGROUND CONCENTRATION FOR ALUMINUM IN SHALLOW GROUNDWATER

0 50 100 200

SCALE IN FEET

ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.2.5
ALUMINUM IN SHALLOW GROUNDWATER
SWMU 162

Date: 06/02/99 | DWG Name: 2911C073

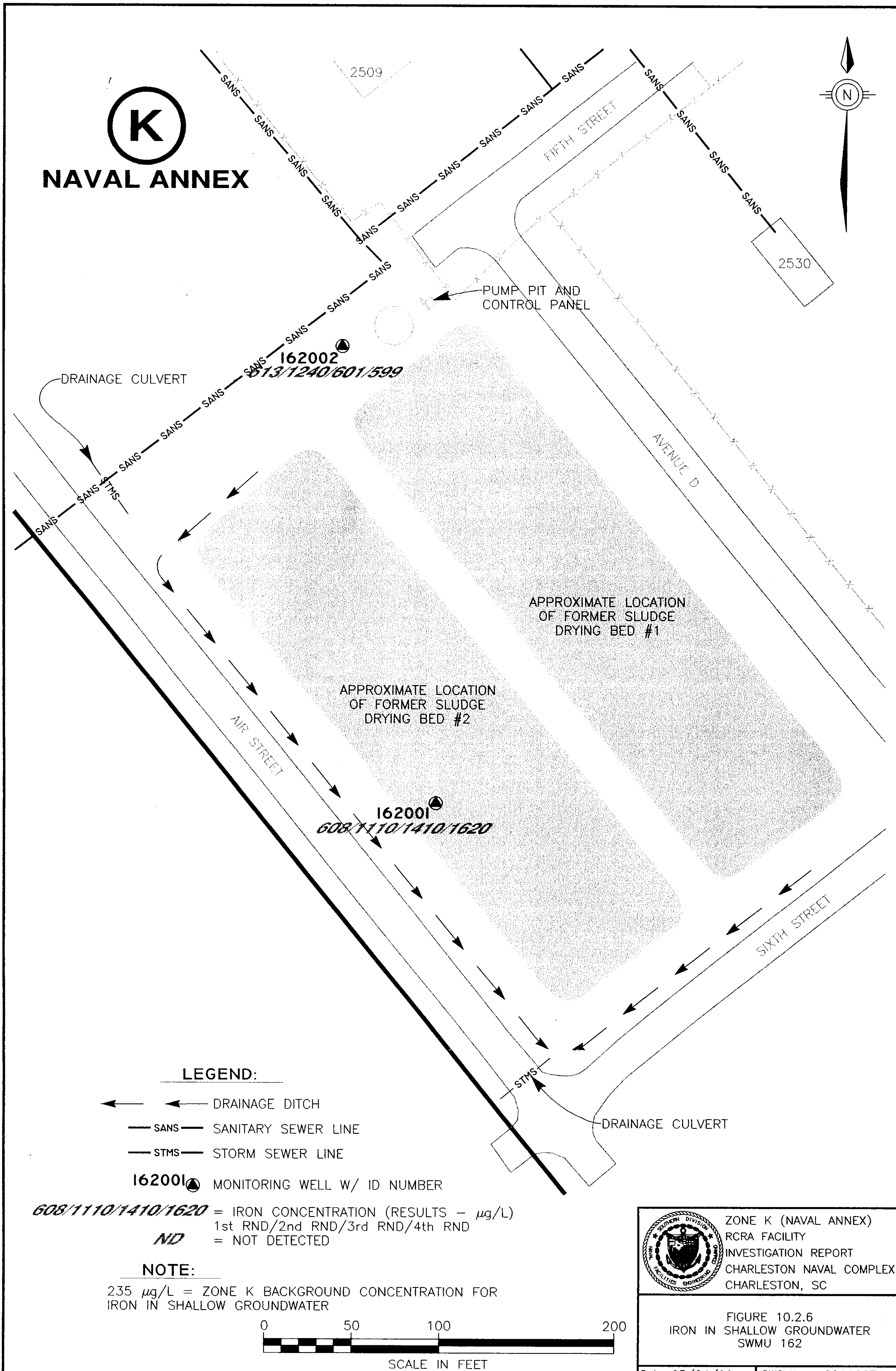

K
NAVAL ANNEX
N
2509
2530
FIFTH STREET
SANS
PUMP PIT AND CONTROL PANEL
162002
613/1240/601/599
DRAINAGE CULVERT
STMS
AVENUE D
APPROXIMATE LOCATION OF FORMER SLUDGE DRYING BED #1
APPROXIMATE LOCATION OF FORMER SLUDGE DRYING BED #2
AIR STREET
162001
608/1110/1410/1620
SIXTH STREET
DRAINAGE CULVERT
LEGEND:
DRAINAGE DITCH
SANS SANITARY SEWER LINE
STMS STORM SEWER LINE
162001 MONITORING WELL W/ ID NUMBER
608/1110/1410/1620 = IRON CONCENTRATION (RESULTS – μg/L)
1st RND/2nd RND/3rd RND/4th RND
ND = NOT DETECTED
NOTE:
235 μg/L = ZONE K BACKGROUND CONCENTRATION FOR IRON IN SHALLOW GROUNDWATER
0 50 100 200
SCALE IN FEET
ZONE K (NAVAL ANNEX)
RCRA FACILITY INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.2.6
IRON IN SHALLOW GROUNDWATER
SWMU 162
Date: 05/24/99
DWG Name: 2911C074

Table 10.2.8
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil-to-Groundwater SSLs, Tap-Water RBCs, and Soil-to-Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: SWMU 162
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurfac Soil	Shallow GW	Screening Concentration Soil-to-GW SSL	Tap-water RBC	Soil-to-Air SSL	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Volatilization Potential
Semivolatile Organic Compounds											
Benzo(g,h,i)perylene	250	ND	ND	5.7E+07 a	730	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)pyrene equivalents (BEQs) c	581	ND	ND	NA	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)anthracene c	480	ND	ND	800	0.092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)pyrene c	440	ND	ND	4000	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(b)fluoranthene c	710	ND	ND	2300 a	0.092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(k)fluoranthene c	420	ND	ND	25000	0.92	NA	UG/KG	UG/L	NO	NO	NO
Chrysene c	510	ND	ND	80000	9.2	NA	UG/KG	UG/L	NO	NO	NO
Indeno(1,2,3-cd)pyrene c	250	ND	ND	7000	0.092	NA	UG/KG	UG/L	NO	NO	NO
Fluoranthene	740	ND	ND	2100000	1500	NA	UG/KG	UG/L	NO	NO	NO
Phenanthrene	164	ND	ND	660000 a	1100	NA	UG/KG	UG/L	NO	NO	NO
Pyrene	610	ND	ND	2100000	1100	NA	UG/KG	UG/L	NO	NO	NO
Pesticides/PCB Compounds											
alpha-Chlordane c	70.1	2.47	ND	5000 b	0.19	20000	UG/KG	UG/L	NO	NO	NO
gamma-Chlordane c	123	ND	ND	5000 b	0.19	20000	UG/KG	UG/L	NO	NO	NO
4,4'-DDD c	147	ND	ND	8000	0.28	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDE c	450	8.67	ND	27000	0.2	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDT c	600	10.3	ND	16000	0.2	1.0E+09	UG/KG	UG/L	NO	NO	NO
Dieldrin c	14.3	ND	ND	2	0.0042	1000	UG/KG	UG/L	YES	NO	NO
Endrin aldehyde	4.24	ND	ND	340 a	11	NA	UG/KG	UG/L	NO	NO	NO
Heptachlor epoxide c	16.8	ND	ND	330	0.0012	5000	UG/KG	UG/L	NO	NO	NO
Dioxin Compounds											
2378-TCDD Equivalents (TEQs) c	3.74	0.027	NA	1600 a	0.45	NA	NG/KG	PG/L	NO	NO	NO
123478-HxCDD c	2.11	ND	NA	4100 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
123678-HxCDD c	4.55	ND	NA	4100 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
123789-HxCDD c	1.38	ND	NA	4100 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDD c	104	ND	NA	110000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDD c	813	26.6	NA	1100000 a	450	NA	NG/KG	PG/L	NO	NO	NO
123478-HxCDF c	8.13	ND	NA	220000 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDF c	21.6	ND	NA	54000 a	45	NA	NG/KG	PG/L	NO	NO	NO
1234789-HpCDF c	2.22	ND	NA	54000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDF c	35	ND	NA	540000 a	450	NA	NG/KG	PG/L	NO	NO	NO
TPH - Diesel Range Organics											
Diesel	22400	ND	ND	NA	NA	NA	UG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.6
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.2.2.

a - Calculated soil-to-groundwater SSL value (See Table 6.4)
b - Based on surrogate compound; see table 5.6
c - Carcinogen
NA - Not available/not applicable
ND - Not detected
RBC - Risk-based concentration

SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.2.9
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil-to-Groundwater SSLs, Tap-Water RBCs, Soil-to-Air SSLs, and Background Reference Values
Charleston Naval Complex, Zone K, Naval Annex: SWMU 162
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurface Soil	Shallow GW	Screening Concentration Soil-to-GW SSL	Soil Background Reference	Soil-to-Air SSL	Tap-water RBC	GW Background Reference	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Fugitive Particulate Inhalation Concern
Inorganics													
Aluminum	9450	15700	881	560000 a	11200	NA	37000	471	MG/KG	UG/L	NO	NO	NO
Arsenic c	3.4	2.5	ND	15	3	750	0.045	NA	MG/KG	UG/L	NO	NO	NO
Barium	19.6	9.3	29	820	25.6	690000	2600	31.2	MG/KG	UG/L	NO	NO	NO
Beryllium	0.09	0.12	ND	32	0.17	1300	73	NA	MG/KG	UG/L	NO	NO	NO
Cadmium	0.34	ND	ND	3.8	0.13	1800	18	NA	MG/KG	UG/L	NO	NO	NO
Chromium (total)	13.2	12	ND	19 b	8.76	270	110	NA	MG/KG	UG/L	NO	NO	NO
Cobalt	1.1	0.91	ND	990 a	0.62	NA	2200	NA	MG/KG	UG/L	NO	NO	NO
Copper	32	0.75	8.9	5600 a	3.86	NA	1500	2.8	MG/KG	UG/L	NO	NO	NO
Lead	23.4	5.6	1.8	400 d	39.6	400	15	1.9	MG/KG	UG/L	NO	NO	NO
Manganese	15.2	8.7	30.8	480 a	26.4	NA	730	9.3	MG/KG	UG/L	NO	NO	NO
Mercury	58.2	0.13	ND	1	NA	10	11	NA	MG/KG	UG/L	YES	NO	YES
Nickel	3.6	4.4	ND	65	2.64	13000	730	NA	MG/KG	UG/L	NO	NO	NO
Silver	ND	ND	12.1	17	0.44	NA	180	NA	MG/KG	UG/L	NO	NO	NO
Tin	11.5	ND	ND	5500 a	19.4	NA	22000	102	MG/KG	UG/L	NO	NO	NO
Vanadium	12.5	19.2	0.92	3000	15.8	NA	260	0.8	MG/KG	UG/L	NO	NO	NO
Zinc	442	ND	26.1	6200	14.8	NA	11000	NA	MG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.7
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.2.3 and 10.2.6.

Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap-water RBCs or corresponding background reference values to determine groundwater migration concern.

a - Calculated soil to groundwater SSL value (See Table 6.2)
b - Assumes hexachrome
c - Carcinogen
d - USEPA de facto residential soil level
GW - Groundwater
NA - Not available/not applicable

ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

No other contaminant fate and transport concerns were identified at SWMU 162.

10.2.6 Human Health Risk Assessment for SWMU 162

10.2.6.1 Site Background and Investigative Approach

This former sludge drying field at Naval Annex was used to dewater wastewater sludge from an Air Force-operated sewage treatment plant. Materials of concern due to past site operations are paint residues, heavy metals, and decomposition gases. A soccer field now occupies the site.

In all, five soil samples were collected from the upper and lower-intervals to identify potential impacts resulting from the activities listed above. As part of the Zone K second-round RFI sampling effort, four additional upper-interval soil samples were collected at SWMU 162. Surface soil samples from all nine boring locations were used to quantitatively assess surface soil exposure pathways. Two monitoring wells were installed in the shallow aquifer. Data from the four quarterly sampling events were used to quantitatively assess groundwater exposure pathways. Sections 10.2.1 and 10.2.3 summarize the sampling effort for SWMU 162 soil and groundwater.

10.2.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 and presented in Table 10.2.10, BEQs, arsenic, and mercury were identified as COPCs in surface soil. Wilcoxon rank sum test analysis resulted in the aluminum being a COPC on the basis of background concentration comparison.

Groundwater

Based on the same screening comparisons, described in Section 7 of this RFI and shown in Table 10.2.11, no COPCs were identified in SWMU 166 shallow groundwater.

Table 10.2.10
Chemicals Present in Site Samples
SWMU 162 - Surface Soil
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
TPH - Diesel Range Organics													
Diesel		2	5	20.2	22.4	21.3	2.75	2.89	NA	NA	MG/KG		
Carcinogenic PAHs													
B(a)P Equiv.	*	3	9	190	581	431	404	439	87	NA	UG/KG	3	
Benzo(a)anthracene		3	9	170	480	348	175	190	870	NA	UG/KG		
Benzo(a)pyrene	*	3	9	140	440	330	175	190	87	NA	UG/KG	3	
Benzo(b)fluoranthene		3	9	250	710	467	175	190	870	NA	UG/KG		
Benzo(k)fluoranthene		2	9	240	420	330	175	190	8700	NA	UG/KG		
Chrysene		3	9	150	510	328	175	190	87000	NA	UG/KG		
Indeno(1,2,3-cd)pyrene		3	9	76	250	172	175	190	870	NA	UG/KG		
TCDD Equivalents													
1234678-HpCDD		1	1	104	104	104	NA	NA	NA	NA	NG/KG		
1234678-HpCDF		1	1	21.6	21.6	21.6	NA	NA	NA	NA	NG/KG		
1234789-HpCDF		1	1	2.22	2.22	2.22	NA	NA	NA	NA	NG/KG		
123478-HxCDD		1	1	2.11	2.11	2.11	NA	NA	NA	NA	NG/KG		
123478-HxCDF		1	1	8.13	8.13	8.13	NA	NA	NA	NA	NG/KG		
123678-HxCDD		1	1	4.55	4.55	4.55	NA	NA	NA	NA	NG/KG		
123789-HxCDD		1	1	1.38	1.38	1.38	NA	NA	NA	NA	NG/KG		
Dioxin Equiv.		1	1	3.7432	3.7432	3.74	NA	NA	1000[b]	NA	NG/KG		
OCDD		1	1	813	813	813	NA	NA	NA	NA	NG/KG		
OCDF		1	1	35	35	35	NA	NA	NA	NA	NG/KG		
Inorganics													
Aluminum (Al)		9	9	5190	9450	7634	NA	NA	7800	11200	MG/KG	5	
Arsenic (As)	*	9	9	0.61	3.4	1.56	NA	NA	0.43	3	MG/KG	9	1
Barium (Ba)		9	9	8.3	19.6	12.0	NA	NA	550	25.6	MG/KG		
Beryllium (Be)		5	9	0.07	0.09	0.084	0.03	0.055	16	0.17	MG/KG		
Cadmium (Cd)		2	9	0.09	0.34	0.22	0.02	0.1	3.9	0.13	MG/KG		1
Calcium (Ca)		9	9	267	2390	971	NA	NA	NA	NA	MG/KG		
Chromium (Cr)		9	9	5	13.2	8.89	NA	NA	23	8.4	MG/KG		6
Cobalt (Co)		4	9	0.76	1.1	0.87	0.065	0.07	470	0.34	MG/KG		4
Copper (Cu)		9	9	1.2	32	7.51	NA	NA	310	3.86	MG/KG		5
Iron (Fe)		9	9	2220	4710	3358	NA	NA	2300	7060	MG/KG		
Lead (Pb)		9	9	4.9	23.4	11.4	NA	NA	400	39.6	MG/KG		
Magnesium (Mg)		9	9	132	337	210	NA	NA	NA	NA	MG/KG		
Manganese (Mn)	a	9	9	5	15.2	7.99	NA	NA	1100	26.4	MG/KG		
Mercury (Hg)	*	7	9	0.06	58.2	9.90	0.025	0.025	2.3	NA	MG/KG	2	
Nickel (Ni)		9	9	1.2	3.6	2.24	NA	NA	160	1.7	MG/KG		8
Potassium (K)		9	9	81.5	203	119	NA	NA	NA	NA	MG/KG		
Sodium (Na)		4	9	14.9	49.7	27.9	7.15	24.8	NA	NA	MG/KG		
Tin (Sn)		2	9	10.9	11.5	11.2	5.1	5.65	4700	19.4	MG/KG		
Vanadium (V)		9	9	6.2	12.5	9.59	NA	NA	55	15.8	MG/KG		
Zinc (Zn)		7	9	20.4	442	86.9	4.35	5.95	2300	14.8	MG/KG		7
Pesticides													
4,4'-DDD		5	5	7.33	147	86.1	NA	NA	2700	NA	UG/KG		
4,4'-DDE		5	5	30.9	450	273	NA	NA	1900	NA	UG/KG		
4,4'-DDT		5	5	27.9	600	351	NA	NA	1900	NA	UG/KG		
alpha-Chlordane		5	5	5.87	70.1	31	NA	NA	1800	NA	UG/KG		
Dieldrin		2	5	6.96	14.3	10.6	1.815	3.6	40	NA	UG/KG		
Endrin aldehyde		1	5	4.24	4.24	4.24	1.815	3.63	2300	NA	UG/KG		
gamma-Chlordane		5	5	21.2	123	63.0	NA	NA	1800	NA	UG/KG		
Heptachlor epoxide		3	5	2.555	16.8	8.35	0.935	1.87	70	NA	UG/KG		
Semivolatile Organics													
Benzo(g,h,i)perylene		2	9	200	250	225	175	190	160000	NA	UG/KG		
Fluoranthene		3	9	310	740	552	175	190	310000	NA	UG/KG		
Phenanthrene		3	9	93	163.5	136	175	190	160000	NA	UG/KG		
Pyrene		3	9	210	610	473	175	190	230000	NA	UG/KG		

Notes:
* - Indicates chemical was identified as a COPC
a - The food RBC was used as a screening value for concentration of manganese reported in soil.
b - Reported soil concentrtions of dioxin (as TEQs) were compared to the project screening level.
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/KG - micrograms per kilogram
MG/KG - milligrams per kilogram
NA - Not applicable or not available

Table 10.2.11
Chemicals Present in Site Samples
SWMU 162 - Shallow Groundwater
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Tap-Water RBC	Reference	Units	Number Exceeding RBC	Ref
Inorganics													
Aluminum (Al)		3	8	369	881	646	78	294	3700	NA	UG/L		
Barium (Ba)		7	8	8.1	29	16.1	22.7	22.7	260	31.4	UG/L		
Calcium (Ca)		8	8	4770	7100	5729	NA	NA	NA	NA	UG/L		
Copper (Cu)		2	8	3.3	8.9	6.1	0.89	4.7	150	NA	UG/L		
Iron (Fe)		8	8	599	1620	975	NA	NA	1100	220	UG/L		
Lead (Pb)		1	8	1.8	1.8	1.8	0.89	1.9	15	NA	UG/L		
Magnesium (Mg)		8	8	569	1300	874	NA	NA	NA	NA	UG/L		
Manganese (Mn)	a	8	8	13	30.8	19.2	NA	NA	73	15.5	UG/L		5
Potassium (K)		8	8	1010	1490	1249	NA	NA	NA	NA	UG/L		
Silver (Ag)		1	8	12.1	12.1	12.1	0.89	3.2	18	NA	UG/L		
Sodium (Na)		4	8	2100	4100	3118	2360	3930	NA	NA	UG/L		
Vanadium (V)		1	8	0.92	0.92	0.92	0.56	0.78	26	NA	UG/L		
Zinc (Zn)		2	8	24.6	26.1	25.4	7.1	55.9	1100	NA	UG/L		

Notes:
a - The nonfood RBC was used as a screening value for concentrations of manganese reported in groundwater
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/L - micrograms per liter
NA - Not applicable or not available

Wilcoxon rank sum test analysis did not result in any parameter being considered a COPC if it had been previously screened out on the basis of background concentration.

10.2.6.3 Exposure Assessment

Exposure Setting

SWMU 162 is located between Fifth and Sixth Streets and D Avenue and Air Street. Because the site has been converted into a soccer field; direct contact with soil is more likely at SWMU 162 than at most other sites at Charleston Naval Complex. All potable water, however, is provided through the city's water supply. Shallow groundwater is not currently used as potable or process water, nor is it likely to be used for this purpose in the future.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents and recreational users. Future site resident and worker exposure scenarios were addressed quantitatively in this risk assessment, as was a recreational-use scenario. Current exposure to workers is discussed qualitatively in relation to the future workers and future residents. The hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact. Therefore, future worker assessment is considered to conservatively represent current site users. The future site resident scenario was built on the premise that existing buildings would be replaced with dwellings.

Exposure Pathways

Exposure pathways for the hypothetical future site residents are dermal contact and incidental ingestion of surface soils. The exposure pathways for current site workers and recreational users are the same as those for the future site worker with respect to soil. The groundwater pathways were excluded because no COPCs were identified. Uniform exposure was assumed for all sample locations. Table 10.2.12 presents the justification for exposure pathways assessed in this HHRA.

Table 10.2.12
Exposure Pathways Summary - SWMU 162
Charleston Naval Complex - Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Users, Maintenance, Recreational Users	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or process water at SWMU 162.
	Shallow groundwater, inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or process water at SWMU 162.
	Soil, incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
Future Land Uses			
Future Site Residents (Child and Adult), Future Site Worker	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Shallow groundwater is not likely to be used as a source of potable or nonresidential water at SWMU 162. Also, no COPCs were identified in shallow groundwater samples at SWMU 162.
	Shallow groundwater, inhalation of volatilized contaminants during domestic use	No	Volatile COPCs were not identified subsequent to risk-based screening comparisons.
	Soil, incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, city limits.
	Fruits and vegetables, ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

Since fewer than 10 surface soil samples were collected, maximum detected concentrations were used as EPCs, as discussed in Section 7 of this RFI.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soils are shown in Tables 10.2.13 and 10.2.14 respectively.

Groundwater

Because no COPCs were identified in four quarterly groundwater samples at SWMU 162, the groundwater pathways were not addressed further in this HHRA.

10.2.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.2.15 presents toxicological information specific to each COPC identified at SWMU 162. This information was used in the quantification of risk/hazard associated with soil contaminants. Each COPC's toxicology is briefly profiled in the following paragraphs.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. The metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuromuscular system controlling bowel muscles. (The effect could explain why aluminum containing antacids often produce constipation and indicates aluminum could affect the uptake of

Table 10.2.13
Chronic Daily Intakes
Incidental Ingestion of Surface Soil
SWMU 162
Charleston Naval Complex - Zone K
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)	Current Recreational H-CDI (mg/kg-day)	Current Recreational C-CDI (mg/kg-day)
Inorganic									
Aluminum (Al)	1	9450	1.3E-02	1.2E-01	1.5E-02	4.6E-03	1.7E-03	6.0E-03	8.5E-04
Arsenic (As)	1	3.4	4.7E-06	4.3E-05	5.3E-06	1.7E-06	5.9E-07	2.2E-06	3.1E-07
Mercury (Hg)	1	58.2	8.0E-05	7.4E-04	9.1E-05	2.8E-05	1.0E-05	3.7E-05	5.3E-06
Semivolatile Organics									
Benzo(a)pyrene equivalents	1	0.58	8.0E-07	7.4E-06	9.1E-07	2.8E-07	1.0E-07	3.7E-07	5.3E-08

NOTES:

LWA Lifetime-weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B.
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.2.14
Chronic Daily Intakes
Dermal Contact with Surface Soil
SWMU 162
Charleston Naval Complex - Zone K
Charleston, South Carolina

Chemical	FI/FC *	Exposure Point Concentration (mg/kg)	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)	Current Recreational H-CDI (mg/kg-day)	Current Recreational C-CDI (mg/kg-day)
Inorganic										
Aluminum (Al)	1	9450	0.001	5.3E-04	1.8E-03	3.3E-04	3.8E-04	1.4E-04	2.8E-04	3.9E-05
Arsenic (As)	1	3.4	0.001	1.9E-07	6.3E-07	1.2E-07	1.4E-07	4.9E-08	9.9E-08	1.4E-08
Mercury (Hg)	1	58.2	0.001	3.3E-06	1.1E-05	2.0E-06	2.3E-06	8.3E-07	1.7E-06	2.4E-07
Semivolatile Organics										
Benzo(a)pyrene equivalents	1	0.58	0.01	3.3E-07	1.1E-06	2.0E-07	2.3E-07	8.3E-08	1.7E-07	2.4E-08

NOTES:
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.
\- The dermal absorption factor was applied to the exposure point concentration to reflect the ability for transdermal migration of inorganic and organic chemicals.

Table 10.2.15
Toxicological Reference Information
for Chemicals of Potential Concern
SWMU 162
Charleston Naval Complex, Zone K
Charleston, South Carolina

	NonCarcinogenic Toxicity Data									*Carcinogenic Toxicity Data*					
Chemical	**Oral Reference Dose (mg/kg-day)**		**Confidence Level**	**Critical Effect**	**Uncertainty Factor Oral**	**Inhalation Reference Dose (mg/kg-day)**	**Confidence Level**	**Critical Effect**	**Uncertainty Factor Inhalation**	**Oral Slope Factor (kg-day/mg)**		**Inhalation Slope Factor (kg-day/mg)**		**Weight of Evidence**	**Tumor Type**
Aluminum	1	d	NA	NA	NA	NA	NA	NA	NA	NA		NA		NA	NA
Arsenic	0.0003	a	M	hyperpigmentation	3	NA	NA	NA	NA	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	NA		NA	NA	NA	NA	NA	NA	NA	7.3	a	6.1	b	B2	mutagen
Mercury	0.0003	a	M	hand tremor and memory disturbances	30	NA	NA	NA	NA	NA		NA		D	NA

Notes:

a = Integrated Risk Information System (IRIS)
b = Withdrawn from IRIS/HEAST
d = EPA-National Center for Environmental Assessment Cincinnati (Provisional).
A = Known human carcincogen
B2 = Possible human carcinogen based on laboratory animal study data.
D = Carcinogenic potential not classifiable.
NA = Not applicable or not available
M = Medium confidence

other chemicals.) Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaasen, et al., 1986; Dreisbach et al., 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg/day. The aesthetic-based secondary MCL for drinking water is 50 to 200 μg/L.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg/day as the RfD for arsenic based on a NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels.

Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg/day)^{-1}$ SF. As listed in IRIS the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic. As listed in IRIS the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Mercury occurs in three forms: elemental, organic, and inorganic. The major source of this element is the degassing of the earth's crust. Organic mercury was not detected at SWMU 162.

Target organs of inorganic mercury include the kidney, nervous system, fetus, and neonate. In other words, this inorganic can be toxic to a fetus if the mother is exposed during pregnancy. Mercury is toxic to all cells in the body — it binds to enzymes in the cells and disrupts their function, usually causing the cell to become useless or die. Because this inorganic is concentrated in the kidney prior to excretion, the kidney is a major target organ for mercury ingestion. The primary target of mercury vapor is the brain. Some forms of mercury are drawn toward fats in the body (such as the nervous system), where it is changed into its toxic form. This causes the nervous disorder known as Minimata disease, overexposure to mercury through ingestion of contaminated fish. The fish ingested inorganic mercury from an industrial discharge, and the inorganic form was metabolized to organic mercury. USEPA set mercury's RfD to 0.0003 mg/kg-day (inorganic form). Mercury is liquid at room temperature, and is poorly absorbed in this form if ingested. Typical daily exposure is less than 1 μg/l-day (Klaassen, et al., 1986) (Dreisbach, et al., 1987).

Benzo(a)pyrene equivalents include the following list of polynuclear aromatic hydrocarbons:

	TEF
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Dibenz(a,h)anthracene	1.0
Benzo(k)fluoranthene	0.01
Benzo(a)pyrene	1.0
Indeno(1,2,3-cd)pyrene	0.1
Chrysene	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. They have no RfDs due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF of 7.3 $(mg/kg/day)^{-1}$. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS, the basis for the benzo(a)pyrene B2 classification is animal studies. Human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

10.2.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under residential, industrial (site worker), and recreational scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.2.16 and 10.2.17 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for SWMU 162 surface soils is 1E-5. The dermal pathway ILCR is 4E-6. Benzo(a)pyrene equivalents and arsenic were the sole contributors to ILCR projections for the ingestion and dermal pathways.

Table 10.2.16
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 162
Charleston Naval Complex - Zone K
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR	Current Recreational Hazard Quotient	Current Recreational ILCR
Inorganic									
Aluminum (Al)	1	NA	0.013	0.12	NA	0.0046	NA	0.0060	NA
Arsenic (As)	0.0003	1.5	0.016	0.14	8.0E-06	0.0055	8.9E-07	0.0072	4.6E-07
Mercury (Hg)	0.0003	NA	0.27	2.5	NA	0.095	NA	0.12	NA
Semivolatile Organics									
Benzo(a)pyrene equivalent	NA	7.3	NA	NA	6.6E-06	NA	7.4E-07	NA	3.8E-07
SUM Hazard Index/ILCR			0.3	3	1E-05	0.1	2E-06	0.14	8E-07

NOTES:
NA Not available
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.
ILCR Incremental Lifetime Cancer Risk

Table 10.2.17
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 162
Charleston Naval Complex - Zone K
Charleston, South Carolina

Chemical	Dermal[a] Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR	Current Recreational Hazard Quotient	Current Recreational ILCR
Inorganic										
Aluminum (Al)	0.2	0.20	NA	0.0027	0.0088	NA	0.0019	NA	0.0014	NA
Arsenic (As)	0.2	0.00006	7.5	0.0032	0.011	9.0E-07	0.0023	3.7E-07	0.0017	1.1E-07
Mercury (Hg)	0.2	0.00006	NA	0.054	0.18	NA	0.039	NA	0.028	NA
Semivolatile Organics										
Benzo(a)pyrene equivalents	0.5	NA	14.6	NA	NA	3.0E-06	NA	1.2E-06	NA	3.5E-07
SUM Hazard Index/ILCR				0.06	0.2	4E-06	0.04	2E-06	0.03	5E-07

NOTES:
NA Not available
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.
ILCR Incremental Lifetime Cancer Risk
[a] Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency, which should not be applied to dermal exposure and dermal CDI).

The ingestion HIs projected for the adult and child receptors are 0.3 and 3, respectively. The dermal pathway HIs were 0.06 for the adult resident receptor and 0.2 for the child resident receptor. Mercury was the primary contributor to HI projections at SWMU 162, while aluminum and arsenic were secondary contributors.

Hypothetical Site Workers

Site worker ILCRs are 2E-6 for both the ingestion and dermal contact pathways. Benzo(a)pyrene equivalents and arsenic were the sole contributors for each pathway.

Site worker HIs are 0.1 for the ingestion pathway and 0.04 for the dermal pathway. Mercury was the primary contributor to site worker HI projections at SWMU 162 and aluminum and arsenic were secondary contributors.

Current Recreational Users

The ingestion ILCR for SWMU 162 surface soil is 8E-7. The dermal pathway ILCR is 5E-7. Benzo(a)pyrene equivalents and arsenic were the only contributors to ILCR projections for the ingestion and dermal pathways.

The ingestion HI projected for the recreational scenario is 0.1. The dermal pathway HI was 0.03. Mercury, aluminum, and arsenic contributed to projected hazard indices.

Groundwater Pathways

Since no COPCs were identified in four quarterly groundwater samples, groundwater pathways were not quantitatively assessed in this HHRA.

COCs Identified

Identification of chemicals of concern was based on cumulative (all pathway) risk and hazard projected for this site on a medium-specific basis. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). As recommended by SCDHEC, a COC was considered to be any chemical contributing to a cumulative risk level of at least 1E-6 and/or a cumulative hazard index exceeding 1.0, if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to more comprehensively evaluate chemicals contributing to carcinogenic risk or noncarcinogenic hazard during remedial goal options development. Table 10.2.18 presents the COCs identified for SWMU 162 surface soil.

Surface Soils

Future Site Residents

Benzo(a)pyrene equivalents and arsenic were identified as soil pathway COCs based on their contribution to cumulative residential ILCR projections. Mercury, aluminum, and arsenic were identified as soil pathway COCs based on their contribution to cumulative residential HI projections.

Future Site Workers

Benzo(a)pyrene equivalents were identified as the only soil pathway COCs based on their contribution to cumulative industrial ILCR projections.

Current Recreational Users

No COCs were identified for the recreational exposure pathway scenario.

Table 10.2.18
Summary of Risk and Hazard-based COCs
SWMU 162
Charleston Naval Complex - Zone K
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient (HI)	Future Resident Child Hazard Quotient (HI)	Future Resident LW ILCR	Current Site Worker Hazard Quotient	Current Site Worker ILCR	Current Recreational Hazard Quotient	Current Recreational ILCR	Identification of COCs
Surface Soil	Incidental Ingestion	**Inorganic**								
		Aluminum (Al)	0.013	0.12	ND	0.0046	ND	0.006	ND	1
		Arsenic (As)	0.016	0.14	8E-06	0.0055	9E-07	0.0072	5E-07	1 2
		Mercury (Hg)	0.27	2.5	ND	0.095	ND	0.12	ND	1
		Semivolatile Organics								
		Benzo(a)pyrene equivalents	ND	ND	7E-06	ND	7E-07	NA	4E-07	2
	Dermal	**Inorganic**								
		Aluminum (Al)	0.0027	0.0088	ND	0.0019	ND	0.0014	ND	
		Arsenic (As)	0.0032	0.011	9E-07	0.0023	4E-07	0.0017	1E-07	
		Mercury (Hg)	0.054	0.18	ND	0.039	ND	0.028	ND	1
		Semivolatile Organics								
		Benzo(a)pyrene equivalents	ND	ND	3E-06	ND	1E-06	ND	4E-07	2 4
Surface Soil Pathway Sum			0.4	3	2E-05	0.1	3E-06	0.2	1E-06	

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
Identification of COCs
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.
5- Chemical is a COC by virtue of projected recreational use noncarcinogenic hazard.
6- Chemical is a COC by virtue of projected recreational use ILCR.

The extent of the COCs identified in surface soil is briefly discussed below. To facilitate this discussion of the extent of COC concentrations, residential soil RBCs were compared to each reported COC concentration. Benzo(a)pyrene equivalents exceeded the residential RBC in three of nine surface soil samples collected at SWMU 162 (162SB001, 162SB002, and 162SB003). Aluminum exceeded its RBC (7800 mg/kg) in five surface soil samples, but not its background reference value (11200 mg/kg). Arsenic exceeded its RBC (0.43 mg/kg) in all nine surface soil samples. Consequently, arsenic only slightly exceeded its background reference value (3 mg/kg) in one surface soil sample (162SB009) at a concentration of 3.4 mg/kg. Arsenic's mean concentration was less than its background reference value. Mercury exceeded its RBC (2.3 mg/kg) in two of nine surface soil samples (162SB001 and 162SB002).

10.2.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. If this area were to be used as a residential site, surface soil conditions would likely change - the soils could be covered with landscaping soil and/or a house. Consequently, exposure to surface soil conditions as represented by samples collected would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

Groundwater is not currently used at SWMU 162 for potable or industrial purposes. A base-wide system provides drinking and process water to buildings throughout Zone K. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The maximum detected soil constituent concentrations were used as the exposure point concentrations for this site. Use of maximum detected concentrations represent conservative assumptions when applied as the EPC, such that it is unlikely for the maximum detected concentration to be representative of all soil constituents throughout the site.

Frequency of Detection and Spatial Distribution

Benzo(a)pyrene equivalent compounds exceeded risk-based concentrations in three of nine surface soil samples, aluminum exceeded its RBC in five of nine surface soil samples, and arsenic exceeded its RBC in only one of nine surface soil samples. Additionally, mercury exceeded its RBC in two surface soil samples. A background reference value has not been established for mercury at Zone K.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

A conservative screening process was used to identify COPCs for SWMU 162. The potential for eliminating CPSSs with the potential for cumulative HI greater than 1 was addressed for noncarcinogens through the use of RBCs that were reduced one order of magnitude. For carcinogens, the RBCs are based on a conservative target risk of 1E-06. Combining conservative RBCs with maximum detected concentrations minimizes the likelihood of a significant contribution to risk/hazard based on eliminated CPSSs. Of the CPSSs screened and eliminated from formal assessment, no soil constituent was reported at a concentration near its RBC (e.g., within 10% of its RBC).

Groundwater

The same conservative screening process was also used for groundwater. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration close to its RBC (e.g., within 10% of its RBC).

Groundwater is not currently used as a potable water source at SWMU 162, nor is it used at Charleston Naval Complex or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. If residences were constructed onsite and an unfiltered well were installed, it is possible that the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

Background-related Risk

Soil

It is not unusual for naturally occurring or background concentrations of some elements to exceed risk-based concentrations. It is the risk assessment's function to identify excess risk and/or hazard, or that which exceeds background levels.

Groundwater

No constituents exceeded tap-water RBCs in four quarterly groundwater samples; therefore, no constituents were eliminated from consideration in the risk assessment based on background reference values for groundwater.

10.2.6.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 162 were assessed for future site workers, future site residents, and current recreational users under reasonable maximum exposure assumptions. In surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Table 10.2.19 summarizes risk for each soil pathway/receptor group evaluated for SWMU 162.

Soil — Residential Scenario

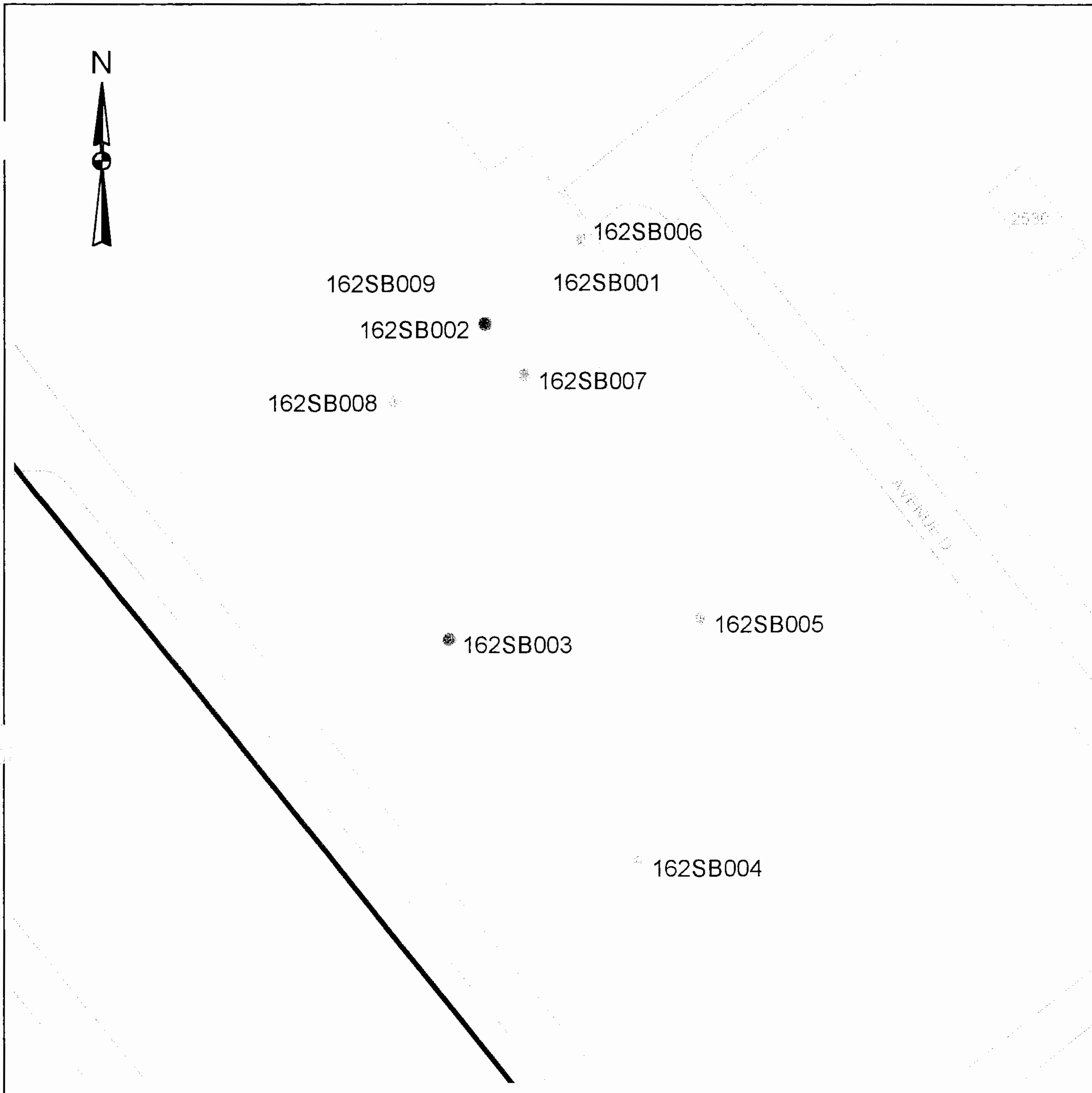
Residential soil pathway COCs identified for SWMU 162 are aluminum, arsenic, mercury and benzo(a)pyrene equivalents. Figure 10.2.7 illustrates point risk estimates for SWMU 162 based on surface soil exposure pathways under a future residential scenario. Table 10.2.20 summarizes the risk and hazard contribution of each COPC at each sample location. This point risk map is based on the unlikely assumption that a potential future site resident will be chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of uniform exposure to the soil conditions of the entire site (or exposure unit area) rather than specific points. Risk maps help the reader visualize how chemicals driving risk estimates are spatially distributed across the site.

Arsenic and benzo(a)pyrene equivalents contributed to risk estimates exceeding 1E-06 at all nine surface soil sample locations. Risk estimates ranged from 2E-06 (162SB008) to 1E-05 (162SB002). The mean risk estimate is 6E-06.

Table 10.2.19
Summary of Risk and Hazard
SWMU 162
Charleston Naval Complex - Zone K
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)	HI (Recreational)	ILCR (Recreational)
Surface Soil	Incidental Ingestion	0.3	3	1E-05	0.11	2E-06	0.14	8E-07
	Dermal Contact	0.06	0.2	4E-06	0.04	2E-06	0.03	5E-07
Sum of Soil Pathways		0.4	2.9	2E-05	0.15	3E-06	0.17	1E-06

Notes:
ILCR Incremental lifetime cancer risk
HI Hazard index



LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

50 0 50 100 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.2.7
SWMU 162

POINT RISK ESTIMATES FOR
SURFACE SOIL
RESIDENTIAL SCENARIO

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Table10.2.20
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
SWMU 162
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
162	B001	Aluminum (Al)	8590	MG/KG	0.1178	17.56	NA	
162	B001	Arsenic (As)	1.8	MG/KG	0.0823	12.26	4.7016	59.94
162	B001	B(a)P Equiv.	189.75	UG/KG	NA		3.1423	40.06
162	B001	Mercury (Hg)	10.3	MG/KG	0.4708	70.18	NA	
		Total			0.6709		7.8439	
162	B002	Aluminum (Al)	5190	MG/KG	0.0712	2.55	NA	
162	B002	Arsenic (As)	1.4	MG/KG	0.0640	2.29	3.6568	27.54
162	B002	B(a)P Equiv.	580.91	UG/KG	NA		9.6201	72.46
162	B002	Mercury (Hg)	58.2	MG/KG	2.6602	95.16	NA	
		Total			2.7954		13.2769	
162	B003	Aluminum (Al)	8185	MG/KG	0.1122	62.00	NA	
162	B003	Arsenic (As)	1.35	MG/KG	0.0617	34.09	3.5262	28.93
162	B003	B(a)P Equiv.	523.025	UG/KG	NA		8.6615	71.07
162	B003	Mercury (Hg)	0.155	MG/KG	0.0071	3.91	NA	
		Total			0.1810		12.1877	
162	B004	Aluminum (Al)	6930	MG/KG	0.0950	56.66	NA	
162	B004	Arsenic (As)	1.5	MG/KG	0.0686	40.88	3.9180	100.00
162	B004	B(a)P Equiv.	ND	UG/KG	NA		NA	
162	B004	Mercury (Hg)	0.09	MG/KG	0.0041	2.45	NA	
		Total			0.1677		3.9180	
162	B005	Aluminum (Al)	7940	MG/KG	0.1089	61.68	NA	
162	B005	Arsenic (As)	1.4	MG/KG	0.0640	36.25	3.6568	100.00
162	B005	B(a)P Equiv.	ND	UG/KG	NA		NA	
162	B005	Mercury (Hg)	0.08	MG/KG	0.0037	2.07	NA	
		Total			0.1765		3.6568	
162	B006	Aluminum (Al)	8160	MG/KG	0.1119	60.47	NA	
162	B006	Arsenic (As)	1.2	MG/KG	0.0548	29.64	3.1344	100.00
162	B006	B(a)P Equiv.	ND	UG/KG	NA		NA	
162	B006	Mercury (Hg)	0.4	MG/KG	0.0183	9.88	NA	
		Total			0.1850		3.1344	
162	B007	Aluminum (Al)	9450	MG/KG	0.1296	66.94	NA	
162	B007	Arsenic (As)	1.4	MG/KG	0.0640	33.06	3.6568	100.00
162	B007	B(a)P Equiv.	ND	UG/KG	NA		NA	
162	B007	Mercury (Hg)	ND	MG/KG	NA		NA	
		Total			0.1936		3.6568	
162	B008	Aluminum (Al)	7350	MG/KG	0.1008	76.70	NA	
162	B008	Arsenic (As)	0.61	MG/KG	0.0279	21.22	1.5933	100.00
162	B008	B(a)P Equiv.	ND	UG/KG	NA		NA	
162	B008	Mercury (Hg)	0.06	MG/KG	0.0027	2.09	NA	
		Total			0.1314		1.5933	
162	B009	Aluminum (Al)	6910	MG/KG	0.0948	37.88	NA	
162	B009	Arsenic (As)	3.4	MG/KG	0.1554	62.12	8.8808	100.00
162	B009	B(a)P Equiv.	ND	UG/KG	NA		NA	
162	B009	Mercury (Hg)	ND	MG/KG	NA		NA	
		Total			0.2502		8.8808	

Figure 10.2.8 illustrates point hazard estimates for SWMU 162 based on surface soil exposure pathways under a future residential scenario. Aluminum, arsenic, and mercury contributed to hazard estimates exceeding unity at only one surface soil sample location (162SB002). Hazard estimates ranged from 0.13 (162SB008) to 3 (162SB002). The mean hazard estimate is 0.5.

Soil — Site Worker Scenario

Benzo(a)pyrene equivalents were the only site worker soil pathway COCs identified for SWMU 162. However, benzo(a)pyrene equivalents are considered borderline COCs at SWMU 162, because they do contribute to a cumulative industrial risk slightly above 1E-06 (1.2E-06), yet the maximum detected concentration of benzo(a)pyrene equivalents (581 μg/kg) is not greater than the industrial RBC (780 μg/kg). The average detected concentration of benzo(a)pyrene equivalents is 431 μg/kg, which yields an industrial site worker ILCR of 9E-07. Hence, point estimates for risk and hazard in surface soil via the industrial site worker scenario were not computed for SWMU 162.

Soil — Recreational Scenario

No COCs were identified for the recreational scenario.

10.2.6.8 Remedial Goal Options

Soil

RGOs for carcinogens were based on the lifetime-weighted average site resident or site worker as presented in Table 10.2.21 for surface soils. Hazard-based RGOs were based on the hypothetical child resident or site worker, as noted in the table.

LEGEND

- NO COPCs
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

50 0 50 100 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.2.8
SWMU 162

POINT HAZARD ESTIMATES FOR
SURFACE SOIL
RESIDENTIAL SCENARIO

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Table 10.2.21
Remedial Goal Options for Soil
SWMU 162
Charleston Naval Complex - Zone K
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)$^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options* 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options* 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Inorganic										
Aluminum (Al)	NA	1	9450	218781	72927	7292.7	NA	NA	NA	11200
Arsenic (As)	1.5	0.0003	3.4	66	22	2.2	0.38	3.8	38	9.44
Mercury (Hg)	NA	0.0003	58.2	66	22	2.2	NA	NA	NA	NA
Semivolatile Organic Compounds										
Benzo(a)pyrene equivalents	7.3	NA	0.6	NA	NA	NA	0.06	0.6	6	NA

Worker-Based Remedial Goal Options

Chemical	Slope Factor (mg/kg-day)$^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options* 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options* 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Inorganic										
Aluminum (Al)	NA	1	9450	4348936	1449645	144965	NA	NA	NA	11200
Arsenic (As)	1.5	0.0003	3.4	1305	435	43	2.7	27	271	9.44
Mercury (Hg)	NA	0.0003	58.2	1305	435	43	NA	NA	NA	NA
Semivolatile Organic Compounds										
Benzo(a)pyrene equivalents	7.3	NA	0.6	NA	NA	NA	0.30	3.0	30	NA

NOTES:
EPC Exposure point concentration
NA Not applicable
* Remedial goal options were based on the residential or site worker lifetime-weighted average for carcinogens and the child resident or site worker for noncarcinogens.

10.2.7 Corrective Measures Considerations

For SWMU 162, the upper and lower soil intervals and shallow groundwater were investigated. In all, nine soil samples were collected from the upper and lower-intervals. The area is a grassy field. Two groundwater monitoring wells were sampled at the site. Based on the analytical results and the human health risk assessment, COCs requiring further evaluation through the CMS process were identified for the upper soil interval. The site has been converted to a soccer field.

Benzo(a)pyrene equivalents, aluminum, arsenic, and mercury were identified as COCs in the upper soil interval. BEQs exceeded the residential RBC in three of nine surface soil samples collected (162SB001, 162SB002, and 162SB003). Aluminum exceeded its RBC (7800 mg/kg) in five surface soil samples. Arsenic exceeded its RBC (0.43 mg/kg) in all nine surface soil samples. Mercury exceeded its screening concentrations at two locations (162SB00101 and 162SB00201). The soil pathway cumulative residential exposure risk is 2E-05 and the cumulative HI is 2.9 (resident child). Both are between USEPA's acceptable range of 1E-06 and 1E-04 for risk and 3 and 0.1 for HI.

Residential risk-based remedial goals for surface soil set for BEQs and arsenic were 0.06 mg/kg and 0.38 mg/kg, respectively, based on a target risk of 1E-06. Residential hazard-based remedial goal for surface soil set for aluminum and mercury was 7,293 mg/kg and 2.2 mg/kg respectively based on a target hazard of 0.1 mg/kg. Potential corrective measures, in addition to no further action for soil, and respective COCs are presented in Table 10.2.22.

No COPCs were identified in groundwater samples at SWMU 162.

Table 10.2.22
Potential Corrective Measures for SWMU 162

Medium	Compounds	Potential Corrective Measures
Soil	Arsenic, aluminum, mercury and benzo(a)pyrene equivalents	a) No Action b) Intrinsic remediation and monitoring c) Containment by capping d) Excavation and landfill, if RCRA-nonhazardous waste e) Insitu, chemical and physical treatment f) Exsitu, chemical and physical treatment

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10.3 SWMU 163, Concrete Pit Area, Naval Annex

SWMU 163 consists of a 10-foot x 10-foot x 2-foot uncovered concrete pit, approximately 100 feet north of Building 2513 at Naval Annex (Figure 10.3.1). The pit was used as a less-than-90-day accumulation area for hazardous waste generated at the facility. According to the June 1995 RFA, the unit's concrete base and walls are heavily cracked. The pit was apparently constructed without a cover. No information regarding rainwater handling at this facility was available. No drains or sumps were observed in the pit. Accumulated waste at SWMU 163 included spent solvents and paint wastes containing heavy metals, including arsenic, barium, cadmium, lead, mercury, silver, and chromium. Hazardous waste was accumulated in the unit from the mid-1980s until the spring of 1994, when MOMAG 11 was reclassified as a small quantity hazardous waste generator and a new less-than-180-day accumulation area (SWMU 167) was placed in service. Naval Annex records were thoroughly searched and no additional information pertinent to SWMU 163 was identified. In particular, no information was found concerning when the unit was constructed or any uses of the unit prior to the mid-1980s.

Materials of concern identified in the final RFI work plan for SWMU 163 include solvents, paint wastes, and heavy metals. Potential receptors are current and future site users involved in invasive activities.

To fulfill CSI objectives, soil and groundwater were sampled in accordance with the final RFI work plan and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at SWMU 163.

10.3.1 Soil Sampling and Analysis

Soil was sampled in two rounds at SWMU 163 from the locations shown on Figure 10.3.1. The final RFI work plan proposed collection of five soil samples from the upper-interval (0 to 1 foot) and five from the lower-interval (3 to 5 feet) for the SWMU 163 investigation area. These samples were collected during round one in December 1996. Five additional upper- and lower-interval samples were collected during round two in January 1999 to further evaluate round one organic detections.

First-round samples were submitted for analysis at DQO Level III for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide. One duplicate was collected from boring 163SB005's upper-interval and submitted for Appendix IX analyses at DQO Level IV. Round two samples were analyzed only for VOCs and SVOCs, which included one duplicate from boring 163SB008's lower-interval, which was analyzed for the same parameters. Table 10.3.1 summarizes soil sampling for SWMU 163.

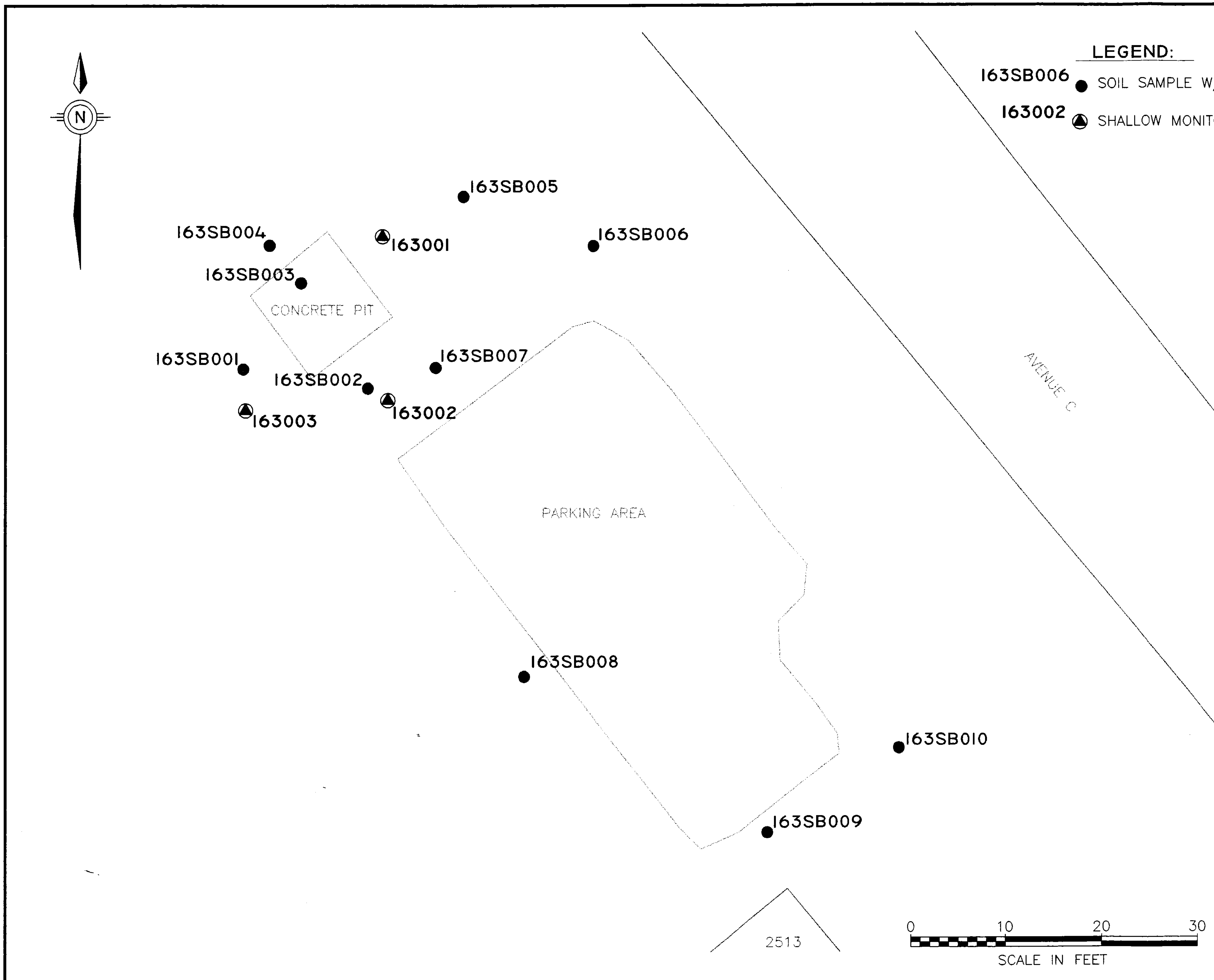
Table 10.3.1
SWMU 163
Soil Sampling Summary

Sampling Round	Sampling Date	Samples Collected	Sample Analyses	Comments
1	12/2/96	Upper - 5 (5) Lower - 5 (5)	Standard Suite	None
		Duplicate - 1	Appendix IX	
2	1/25/99	Upper - 5 (0) Lower - 5 (0)	VOCs and SVOCs.	None
		Duplicate - 1	VOCs and SVOCs	

Notes:
( ) = Parentheses indicate number of samples proposed in RFI Work Plan.
Standard Suite = VOCs, SVOCs, metals, cyanide, pesticides and PCBs.
Appendix IX = Standard Suite plus hex-chrome, herbicides, OP pesticides, and dioxins at DQO Level IV.

10.3.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.3.2. Inorganic analytical results are summarized in Table 10.3.3. Table 10.3.4 summarizes all analytes detected in soil at SWMU 163. Analyte concentrations are listed in bold type if they exceed their respective screening concentrations, the applicable residential soil RBC or SSL and, when available, the associated background concentration. Appendix F is a complete analytical data report for all samples collected in Zone K, including SWMU 163.



ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.3.1
SITE MAP
SWMU 163

Date: 04/16/99 | DWG Name: 2911C056

Table 10.3.2
SWMU 163
Organics Detected in Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
VOCs(μg/kg)						
20 samples collected; 10 upper-interval, 10 lower-interval, 1 duplicate for Appendix IX analysis						
Acetone	Upper	1/10	2,700	2,700	780,000	0
	Lower	0/10	ND		8,000	0
Carbon disulfide	Upper	1/10	1	1	780,000	0
	Lower	0/10	ND		16,000	0
Tetrachloroethene	Upper	4/10	14 - 990	262	12,000	0
	Lower	1/10	6	6	30	0
Trichloroethene	Upper	3/10	5 - 22	11	58,000	0
	Lower	0/10	ND	NA	30	0
SVOCs (μg/kg)						
20 samples collected; 10 upper-interval, 10 lower-interval, 1 duplicate for Appendix IX analysis						
BEQs	Upper	6/10	15 - 389.58	133.83	87	2
	Lower	1/10	312.29	312.29	4,000	0
Benzo(a)anthracene	Upper	3/10	39 - 280	159.67	870	0
	Lower	1/10	300 - 300	300	8,000	0
Benzo(a)pyrene	Upper	3/10	37 - 180	100	87	1
	Lower	1/10	230	230	4,000	0
Benzo(b)fluoranthene	Upper	4/10	52 - 190	90.25	870	0
	Lower	1/10	210	210	2,300	0
Benzo(k)fluoranthene	Upper	3/10	56 - 180	125.33	8,700	0
	Lower	1/10	200	200	25,000	0
Chrysene	Upper	5/10	43 - 400	148	87,000	0
	Lower	1/10	290	290	80,000	0
Dibenz(a,h)anthracene	Upper	1/10	150	150	87	1
	Lower	0/10	ND	NA	800	0
Indeno(1,2,3-cd)pyrene	Upper	5/10	150 - 230	172	870	0
	Lower	1/10	290	290	7,000	0
2-Methylnaphthalene	Upper	1/10	280	280	160,000	0
	Lower	0/10	ND	NA	18,000	0
Acenaphthene	Upper	1/10	46	46	470,000	0
	Lower	1/10	140	140	290,000	0
Acenaphthylene	Upper	1/10	88	88	160,000	0
	Lower	0/10	ND	NA	47,000	0
Anthracene	Upper	1/9	65	65	2,300,000	0
	Lower	1/10	220	220	6,000,000	0
Benzo(g,h,i)perylene	Upper	1/10	78	78	160,000	0
	Lower	1/10	110	110	57,000,000	0

Table 10.3.2
SWMU 163
Organics Detected in Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
bis(2-Ethylhexyl)phthalate (BEHP)	Upper	3/10	41 - 440	179	46,000	0
	Lower	0/10	ND	NA	1,800,000	0
Butylbenzylphthalate	Upper	1/10	160	160	1,600,000	0
	Lower	0/10	ND	NA	930,000	0
Di-n-butylphthalate	Upper	1/9	39	39	780,000	0
	Lower	0/10	ND	NA	2,300,000	0
Dibenzofuran	Upper	1/10	54	54	31,000	0
	Lower	1/10	75	75	6,800	0
Fluoranthene	Upper	5/10	53 - 600	226.4	310,000	0
	Lower	1/10	740	740	2,100,000	0
Fluorene	Upper	1/10	42 - 42	42	310,000	0
	Lower	1/10	98 - 98	98	280,000	0
N-Nitroso-di-n-propylamine	Upper	0/10	ND	NA	91	0
	Lower	2/10	2.3 - 330	166.15	.024	2
Naphthalene	Upper	1/10	140	140	160,000	0
	Lower	0/10	ND	NA	31,000	0
Phenanthrene	Upper	2/9	150 - 210	180	160,000	0
	Lower	1/10	760	760	660,000	0
Phenol	Upper	2/10	120 - 240	180	4,700,000	0
	Lower	2/10	260 - 300	280	50,000	0
Pyrene	Upper	5/10	54 - 400	171	230,000	0
	Lower	1/10	480	480	2,100,000	0

Pesticides (μg/kg)
10 samples collected; 5 upper-interval, 5 lower-interval, 1 duplicate for Appendix IX analysis

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
4,4'-DDD	Upper	2/5	6.59 - 8.21	7.4	2,700	0
	Lower	0/5	ND	NA	8,000	0
4,4'-DDE	Upper	3/5	5.1 - 53.3	21.8	1,900	0
	Lower	0/5	ND	NA	27,000	0
4,4'-DDT	Upper	3/5	9.12 - 55.3	29.9	1,900	0
	Lower	0/5	ND	NA	16,000	0

Table 10.3.2
SWMU 163
Organics Detected in Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Dioxin (ng/kg)						
1 upper-interval sample was collected for dioxin (duplicate sample).						
TCDD TEQ	Upper	1/1	0.067	NA	4.3	0

Notes:
NA = Not Applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed
μg/kg = Micrograms per kilogram
ng/kg = Nanograms per kilogram

Table 10.3.3
SWMU 163
Inorganics Detected in Soil
(all concentrations in mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Metals							
10 Samples Collected, 5 upper-interval, 5 lower-interval, 1 duplicate for Appendix IX analysis							
Aluminum	Upper	5/5	5,210 - 10,000	7,884	11,200	7,800	0
	Lower	5/5	3,430 - 6,690	4844	10,500	560,000	0
Antimony	Upper	1/5	3.3	NA	0.45	3.1	1
	Lower	0/5	ND	NA	**	2.7	0
Arsenic	Upper	5/5	1.2 - 3.3	2.15	3.00	0.43[a]	1
	Lower	4/5	0.56 - 1.8	1.04	1.98	15	0
Barium	Upper	5/5	13.75 - 49.4	25.47	25.6	550	0
	Lower	5/5	2.6 - 6.9	4.26	6.83	820	0
Beryllium	Upper	1/5	0.27	NA	0.17	16.0	0
	Lower	0/5	ND	NA	0.12	32	0
Cadmium	Upper	3/5	0.53 - 1	0.75	0.13	3.9	0
	Lower	0/5	ND	NA	**	4.0	0
Calcium	Upper	5/5	870 - 5,180	3,028	NA	NL	NA
	Lower	5/5	61.1 - 173	106	NA	NL	NA

Table 10.3.3
SWMU 163
Inorganics Detected in Soil
(all concentrations in mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Chromium	Upper	5/5	5.6 - 21.5	12.43	8.4	23	0
	Lower	5/5	2.9 - 8.4	4.98	8.76	19.0	0
Cobalt	Upper	5/5	0.5 - 5.4	2.0	0.34	470	0
	Lower	5/5	0.2 - 1.3	0.85	0.62	990	0
Copper	Upper	3/5	4.2 - 14.4	7.7	3.86	310	0
	Lower	0/5	ND	NA	0.34	5,600	0
Iron	Upper	5/5	2,820 - 5,430	4,076	7,060	2,300	0
	Lower	5/5	659 - 2,070	1,562	5,130	NL	0
Lead	Upper	5/5	8.55 - 149	48.9	39.6	400[h]	0
	Lower	5/5	2.1 - 4.1	3.3	6.43	400***	0
Magnesium	Upper	5/5	72.6 - 324	240.3	NA	NL	NA
	Lower	5/5	35.5 - 169	127.7	NA	NL	NA
Manganese	Upper	5/5	4.6 - 33.9	17.85	26.4	160	0
	Lower	5/5	0.87 - 12.8	6.4	5.93	480	0
Mercury	Upper	1/5	0.07	NA	**	2.3	0
	Lower	0/5	ND	NA	**	1.0	0
Nickel	Upper	5/5	1.6 - 4.7	2.87	1.70	160	0
	Lower	5/5	0.81 - 2.3	1.5	2.64	65.0	0
Potassium	Upper	5/5	53 - 144	114	NA	NL	NA
	Lower	4/5	46 - 101	74.8	NA	NL	NA
Selenium	Upper	2/5	0.5 - 0.56	0.53	0.84	39	0
	Lower	0/5	ND	NA	0.52	2.6	0
Sodium	Upper	4/5	49.7 - 96.8	68.4	NA	NL	0
	Lower	0/5	ND	NA	NA	NL	0
Vanadium	Upper	5/5	7.9 - 13.8	11.5	15.8	55	0
	Lower	5/5	2.7 - 6.6	4.4	12.2	3,000	0

Table 10.3.3
SWMU 163
Inorganics Detected in Soil
(all concentrations in mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Zinc	Upper	5/5	10.7 - 268	90.9	14.8	2,300	0
	Lower	1/5	18.1	NA	**	6,200	0

Notes:

a = RBC for arsenic as a carcinogen
b = RBC not available for lead. USEPA residential soil cleanup level was used for comparison (OSWER Directive 9355.4-12).
*** = SSL value was not based on target leachate concentration.
ND = Not detected/not determined
NA = Not applicable/not available/not analyzed
NL = Not listed
** = Number of nondetects prevented determination of reference concentration.
mg/kg = Milligrams per kilograms.

Table 10.3.4
SWMU 163
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Volatile Organic Compounds (μg/kg)							
Acetone	163SB010	2,700	780,000	NA	ND	8,000	NA
Carbon Disulfide	163SB010	1	780,000	NA	ND	16,000	NA
Tetrachloroethene	163SB001	14	12,000	NA	6	30	NA
	163SB002	16			ND		
	163SB003	990			ND		
	163SB004	28			ND		
Trichloroethene	163SB002	5	58,000	NA	ND	30.0	NA
	163SB003	22			ND		
	163SB004	6			ND		
Semivolatile Organic Compounds (μg/kg)							
BEQs	163SB001	**113.2**	87	NA	ND	4,000	NA
	163SB006	15.0			ND		
	163SB007	21.75			ND		
	163SB008	**389.58**			312.29		
	163SB009	63.73			ND		
	163SB010	21.24			ND		
Benzo(a)anthracene	163SB001	280	870	NA	ND	8,000	NA
	163SB008	160			300		
	163SB009	39			ND		
Benzo(a)pyrene	163SB001	83	87	NA	ND	4,000	NA
	163SB008	**180**			230		
	163SB009	37			ND		

Table 10.3.4
SWMU 163
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Benzo(b)fluoranthene	163SB007	57	870	NA	ND	2,300	NA
	163SB008	190			210		
	163SB009	62			ND		
	163SB010	52					
Benzo(k)fluoranthene	163SB001	180	8,700	NA	ND	25,000	NA
	163SB008	140			200		
	163SB009	56			ND		
Chrysene	163SB001	400	87,000	NA	ND	8,000	NA
	163SB007	52			ND		
	163SB008	180			290		
	163SB009	65			ND		
	163SB010	43			ND		
Dibenz(a,h)anthracene	163SB008	**150**	87	NA	ND	800	NA
Indeno(1,2,3-cd)pyrene	163SB006	150	870	NA	ND	7,000	NA
	163SB007	160			ND		
	163SB008	230			290		
	163SB009	160			ND		
	163SB010	160			ND		
2-Methylnaphthalene	163SB007	280	160,000	NA	ND	18,000	NA
Acenaphthene	163SB008	46	470,000	NA	140	290,000	NA
Acenaphthylene	163SB001	88	160,000	NA	ND	47,000	NA
Anthracene	163SB008	65	2,300,000	NA	220	6,000,000	NA
Benzo(g,h,i)perylene	163SB008	78	160,000	NA	110	57,000	NA

Table 10.3.4
SWMU 163
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
bis(2-Ethylhexyl)phthalate(BEHP)	163SB007	41	46,000	NA	ND	1,800,000	NA
	163SB008	56			ND		
	163SB009	440			ND		
Butylbenzylphthalate	163SB009	160	1,600,000	NA	ND	930,000	NA
Dibenzofuran	163SB007	54	31,000	NA	ND	6,800	NA
	163SB008	ND			75		
Di-n-butylphthalate	163SB009	39	780,000	NA	ND	2,300,000	NA
Fluoranthene	163SB001	600	310,000	NA	ND	2,100,000	NA
	163SB007	53			ND		
	163SB008	330			740		
	163SB009	92			ND		
	163SB010	57			ND		
Fluorene	163SB008	42	310,000	NA	98	280,000	NA
Naphthalene	163SB007	140	160,000	NA	ND	31,000	NA
N-Nitroso-di-n-propylamine	163SB002	ND	91	NA	**330**	.024	NA
	163SB003	ND			**620**		
Phenanthrene	163SB007	150	160,000	NA	ND	660,000	NA
	163SB008	210			760		
Phenol	163SB004	120	4,700,000	NA	300	50,000	NA
	163SB005	240			260		
Pyrene	163SB001	400	230,000	NA	ND	2,100,000	NA
	163SB007	54			ND		
	163SB008	250			480		
	163SB009	93			ND		
	163SB010	58			ND		

Table 10.3.4
SWMU 163
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Pesticides/PCBs (µg/kg)							
4,4-DDD	163SB002	8.21	2,700	NA	ND	8,000	NA
	163SB004	6.59			ND		
4,4-DDE	163SB001	5.1	1,900	NA	ND	27,000	NA
	163SB002	53.3			ND		
	163SB004	7.02			ND		
4,4-DDT	163SB001	9.12	1,900	NA	ND	16,000	NA
	163SB002	25.3			ND		
	163SB004	55.3			ND		
Dioxin Compounds (ng/kg)							
TCDD TEQ	163SB005	0.067	4.3	NA	NT	1,600	NA
1234678-HpCDD	163SB005	1.76	430	NA	NT	110,000	NA
1234678-HpCDF	163SB005	0.58	430	NA	NT	54,000	NA
234678-HxCDF	163SB005	0.24	43	NA	NT	220,000	NA
OCDD	163SB005	19.8	4,300	NA	NT	1,100,000	NA
OCDF	163SB005	0.692	4,300	NA	NT	540,000	NA

Table 10.3.4
SWMU 163
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Inorganics (mg/kg)							
Aluminum (Al)	163SB001	7,790	7,800	11,200	4,300	560,000	10,500
	163SB002	7,970			4,540		
	163SB003	5,210			5,260		
	163SB004	10,000			6,690		
	163SB005	8,450			3,430		
Antimonoy (Sb)	163SB002	**3.3**	3.1	0.45	ND	2.7	NA
Arsenic (As)	163SB001	2.9	0.43[a]	3.0	0.6	15	1.98
	163SB002	3.3			0.56		
	163SB003	1.2			ND		
	163SB004	1.9			1.8		
	163SB005	1.45			1.2		
Barium (Ba)	163SB001	20.1	550	25.6	2.6	820	6.83
	163SB002	49.4			2.8		
	163SB003	23.3			5.3		
	163SB004	20.8			6.9		
	163SB005	13.75			3.7		
Beryllium (Be)	163SB002	0.27	16	0.17	ND	32	0.12
Cadmium (Cd)	163SB001	0.53	3.9	0.13	ND	4	NA
	163SB002	0.73			ND		
	163SB003	1			ND		
Calcium (Ca)	163SB001	5,180	NL	NA	70.8	NA	NA
	163SB002	4,110			173		
	163SB003	870			95.4		
	163SB004	2,720			61.1		
	163SB005	2,260.5			130		

Table 10.3.4
SWMU 163
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Chromium (Cr)	163SB001	13.3	23	8.4	4.2	19	8.76
	163SB002	21.5			4.6		
	163SB003	5.6			4.8		
	163SB004	14.4			8.4		
	163SB005	7.35			2.9		
Cobalt (Co)	163SB001	0.66	470	0.34	0.2	990	0.62
	163SB002	1.4			0.89		
	163SB003	2.1			1.1		
	163SB004	5.4			1.3		
	163SB005	0.5			0.8		
Copper (Cu)	163SB001	4.5	310	3.86	ND	5,600	0.34
	163SB002	14.4			ND		
	163SB004	4.2			ND		
Iron (Fe)	163SB001	5,430	2,300	7,060	659	NA	5,130
	163SB002	5,300			2,070		
	163SB003	2,970			1,360		
	163SB004	3,860			2,050		
	163SB005	2,820			1,670		
Lead (Pb)	163SB001	20.1	400[b]	39.6	3	400***	6.43
	163SB002	149			3.5		
	163SB003	41.7			3.8		
	163SB004	25.3			4.1		
	163SB005	8.55			2.1		
Magnesium (Mg)	163SB001	202	NL	NA	35.5	NA	NA
	163SB002	319			123		
	163SB003	72.6			168		
	163SB004	324			169		
	163SB005	284			143		

Table 10.3.4
SWMU 163
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Manganese (Mn)	163SB001	10	160	26.4	0.87	480	5.93
	163SB002	33.9			3.4		
	163SB003	4.6			11.2		
	163SB004	27.4			12.8		
	163SB005	13.35			3.6		
Mercury (Hg)	163SB002	0.07	2.3	NA	ND	1	NA
Nickel (Ni)	163SB001	2.3	160	1.7	0.81	65	2.64
	163SB002	4.7			1.9		
	163SB003	1.6			1.7		
	163SB004	3.2			2.3		
	163SB005	2.55			0.86		
Potassium (K)	163SB001	110	NL	NA	ND	NA	NA
	163SB002	134			52.3		
	163SB003	53			101		
	163SB004	130			100		
	163SB005	144			46		
Selenium (Se)	163SB002	0.5	39	0.84	ND	2.6	0.52
	163SB004	0.56			ND		
Sodium (Na)	163SB001	96.8	NL	NA	ND	NA	NA
	163SB002	72.4			ND		
	163SB004	54.9			ND		
	163SB005	49.65			ND		
Vanadium (V)	163SB001	13.8	55	15.8	2.7	3,000	12.2
	163SB002	12.1			4.4		
	163SB003	7.9			4		
	163SB004	12.5			6.6		
	163SB005	11.25			4.4		

Table 10.3.4
SWMU 163
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Zinc (Zn)	163SB001	28.9	2,300	14.8	ND	6,200	NA
	163SB002	124			ND		
	163SB003	268			18.1		
	163SB004	22.9			ND		
	163SB005	10.65			ND		

Notes:
a = RBC for arsenic as a carcinogen
b = Charleston Naval Complex project screening level
* = Residential RBCs (THQ = 0.1) were used as a reference concentration for upper-interval samples. Generic soil-to-groundwater SSLs (DAF=10) from *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as a reference concentration for lower-interval samples.
*** = SSL not based on Target leachate concentration

Bold concentrations exceed the RBCs, SSL, and the zone background.
All background values for Zone K are based on twice the means of the grid sample concentrations.

DAF = Dilution attenuation factor
NA = Not Applicable/not available/not analyzed
ND = Not detected/not determined
NT = Not taken
NL = Not listed
RBC = Risk-based concentration
SSL = Soil screening level
THQ = Target hazard quotient
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
ng/kg = Nanograms per kilogram

Volatile Organic Compounds in Soil

Tetrachloroethene and trichloroethene, the only VOCs detected during round one soil sampling at SWMU 163, did not exceed their screening levels. The majority of the VOC detections were from the upper-interval, with one tetrachloroethene detection in the lower-interval. The highest tetrachloroethene detection was from the upper-interval sample directly below the base of the concrete pit. Tetrachloroethene and trichloroethene were not detected in round two samples. However, concetrations of acetone and carbon disulfide, also below applicable screening levels, were detected during round two.

Semivolatile Organic Compounds in Soil

Twenty-three SVOCs were detected in soil at SWMU 163. Most SVOCs were detected in upper-interval samples, generally during round two. All round one SVOC detections occurred in the upper-interval, except for one compound (n-nitroso-di-n-propylamine) detected in two lower-interval samples (from locations 163SB002 and 003). No round one upper-interval detections exceeded their RBCs. However, the lower-interval detections of n-nitroso-di-n-propylamine exceeded the SSL for that compound. Several additional SVOCs were detected during round two; most of were again were in the upper-interval. Two upper-interval rounds two detections [benzo(a)pyrene and dibenz(a,h)anthracene] exceeded applicable RBCs. Both exceedances were in the sample from location 163SB008. Several SVOCs were also detected in the lower-interval sample from location 163SB008. However, no round two lower-interval detection exceeded an applicable SSL.

BEQs were calculated for all samples (one round one sample [163SB001] and all round two samples) that contained carcinogenic PAHs. BEQs for two samples (163SB001 and 163SB008) exceeded the applicable RBC for benzo(a)pyrene (87μg/kg). Figure 10.3.2 shows BEQ values calculated for surface soil sample locations.

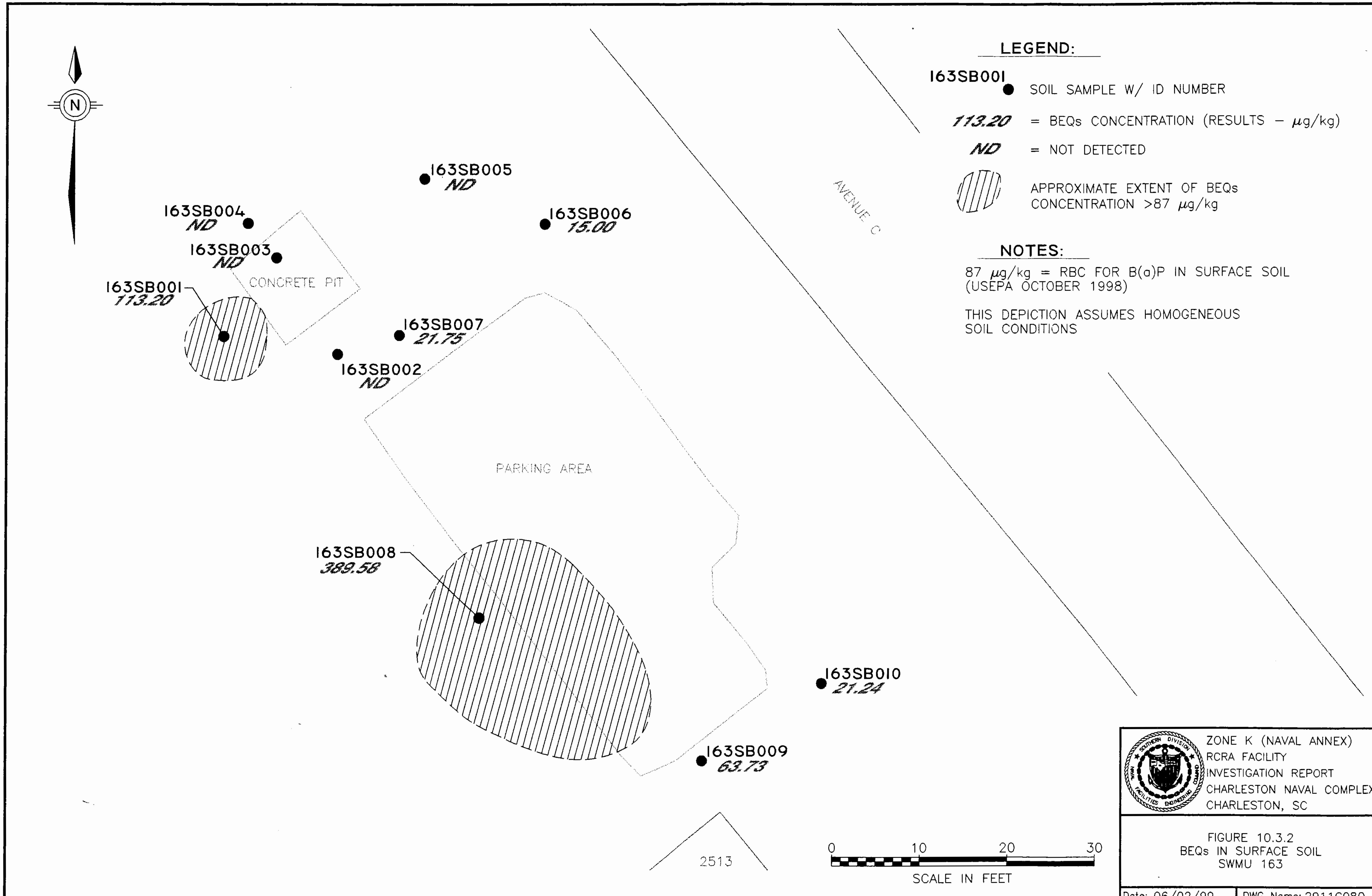


FIGURE 10.3.2
BEQs IN SURFACE SOIL
SWMU 163

Pesticides/PCBs in Soil

Three pesticides were detected in round one soil samples. DDD, DDE, and DDT were detected in upper-interval samples. None exceeded its respective RBC screening levels. Round two samples were not analyzed for pesticides.

No PCBs were detected in the soil samples from SWMU 163.

Other Organic Compounds in Soil

Several dioxin compounds were detected in the round one duplicate sample. The calculated TCDD TEQ was three orders of magnitude less than the 2,3,7,8-TCDD RBC of 4.3 μg/kg.

Inorganics in Soil

Only two inorganics in surface soil exceeded their RBC and background concentrations. Both antimony and arsenic exceedances (3.3 μg/kg) occurred in the upper-interval sample from location 163SB002. Aluminum and iron also exceeded their RBCs, but did not their the surface background concentration.

Cobalt, barium, and manganese in subsurface samples exceeded applicable background concentrations; however, none exceeded its SSL. All soil exceedances were within an order of magnitude of their reference concentration.

10.3.3 Groundwater Sampling and Analysis

The final RFI work plan proposed the installation of one shallow monitoring well and one DPT sampling location for SWMU 163. The permanent monitoring well is located on the northeast side of the concrete pit, where the pit would have overflowed if a large volume of liquids was released inside it. The DPT sampling location is on the southwest side of the pit. Two additional wells were installed adjacent to the pit for a fifth groundwater sampling event in 1999. Only shallow groundwater was sampled at each location. Groundwater sample locations are illustrated on Figure 10.3.1.

NBCK163001 was developed in December 1996 and sampled in January 1997. After installation and development of the monitoring well proposed in the final RFI work plan, the first-round samples were collected and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and TPH at DQO Level III. The DPT sample was collected November 1996 and analyzed for VOCs.

Second-round samples were collected by the CEERD in April 1997. Third- and fourth-round samples were collected in July and October 1997, respectively. Second- through fourth-round groundwater samples were also analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and TPH at DQO Level III. Fifth-round samples were collected in March 1999 and analyzed only for VOCs and SVOCs. Table 10.3.5 summarizes groundwater sampling at SWMU 163.

The shallow monitoring wells were installed at 15 feet bgs in the water table aquifer as described in Section 3.3 of this report. The screening level sample was collected from approximately 10 feet bgs. The screening sample was collected as described in Section 3.2.6.

Table 10.3.5
SWMU 163
Groundwater Sampling Summary

Sampling Round	Sampling Date	Wells Sampled	Sample Analyses	Comments
1	11/21/96	163GP003	VOCs and metals	163GP001 was a screening sample (DPT).
	1/3/97	163GW001	Standard Suite and TPH	
2	4/17/97	163GW001[a]	Standard Suite and TPH	None
3	7/28/97	163GW001[b]	Standard Suite	None
4	10/23/97	163GW001[b]	Standard Suite	None

Table 10.3.5
SWMU 163
Groundwater Sampling Summary

Sampling Round	Sampling Date	Wells Sampled	Sample Analyses	Comments
5	3/24/99	163GW002 163GW003	VOCs and SVOCs	Two additional wells installed and sampled only during round five.

Notes:
a = Duplicate sample collected and analyzed for Appendix IX analyses at DQO Level IV (Standard Suite plus hex-chrome, dioxins, OP pesticides, and herbicides).
b = Duplicate sample collected and analyzed for the same parameters.

10.3.4 Nature and Extent of Contamination in Groundwater

Table 10.3.6 summarizes organic groundwater analytical results and Table 10.3.7 summarizes inorganic analytical results for SWMU 163. Table 10.3.8 summarizes all analytes detected in shallow groundwater at SWMU 163. Analyte concentrations are listed in bold type if they exceeded their screening concentrations, the lower of the applicable tap-water RBC or MCL and, when available, the associated shallow groundwater background concentration. Appendix F is a complete analytical data report for all samples collected in Zone K, including those collected at SWMU 163.

Volatile Organic Compounds in Groundwater

No VOCs were detected in groundwater samples collected at SWMU 163 during rounds one through four. However, three VOCs were detected in samples from the two additional wells during round five: 1,2-dichloroethene, tetrachloroethene, and trichloroethene. At least one concentration of each exceeded an applicable RBC and MCL. Figure 10.3.3 shows VOCs concentrations detected in shallow groundwater during round five.

Table 10.3.6
SWMU 163
Organics Detected In Groundwater

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and Background
Volatile Organic Compounds (μg/L)							
1,2-Dichloroethene	Mar. 99	2/2	2 - 480	241	5.5 / 70	NA	1
Tetrachloroethene	Mar. 99	2/2	2 - 47	24.5	1.1 / 5	NA	2
Trichloroethene	Mar. 99	½	170	170	1.65 / 5	NA	1
Semivolatile Organic Compounds (μg/L)							
Benzoic Acid	Oct. 97	1/1	6.5	6.5	15,000 / NL	NA	0
bis(2-Ethylhexyl)phthalate	Mar. 99	½	41	41	4.8 / 6	NA	1
butylbenzylphthalate	Mar. 99	½	0.6	0.6	7,300 / NL	NA	0
Di-n-butylphthalate	Mar. 99	2/2	0.7	0.7	3,700 / NL	NA	0
Dioxin (pg/L)							
TCDD TEQ	April 97	1/1	.00617	NA	0.45 / 30	NA	0

Notes:
NA = Not applicable/not available/not analyzed
NL = Not listed
μg/L = Micrograms per liter

Table 10.3.7
SWMU 163
Inorganics Detected In Groundwater

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and Background
Inorganics (1 monitoring well sampled during Rounds 1 through 4)							
Aluminum	Jan. 97	1/1	248	248	3,700/NL	471	0
	April 97	0/1	NA	NA			0
	July 97	0/1	NA	NA			0
	Oct. 97	1/1	504	504			0
Arsenic	Jan. 97	1/1	1.8	1.8	0.045/50	NA	1
	April 97	0/1	NA	NA			0
	July 97	0/1	NA	NA			0
	Oct. 97	0/1	NA	NA			0

Table 10.3.7
SWMU 163
Inorganics Detected In Groundwater

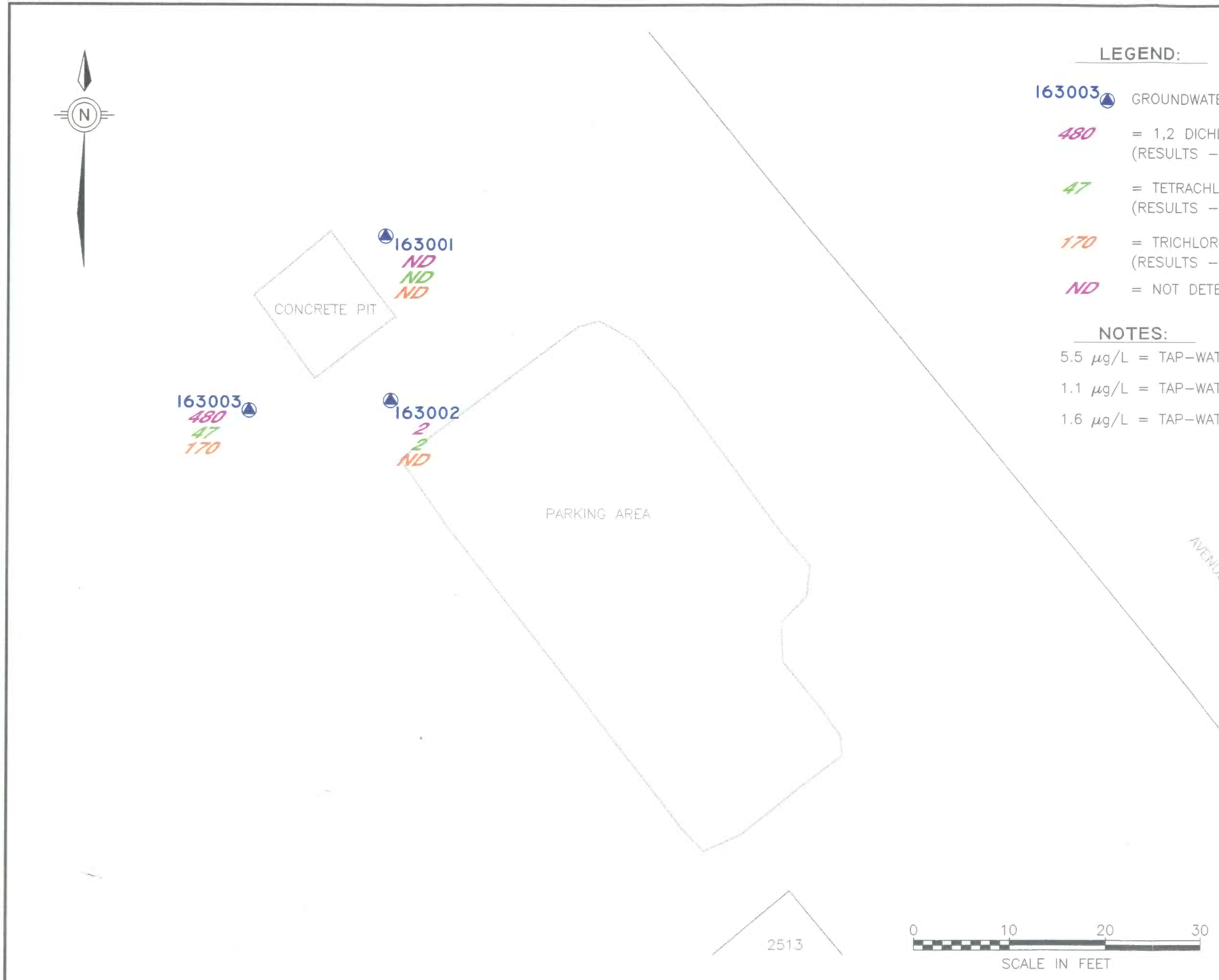
Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and Background
Inorganics (1 monitoring well sampled during Rounds 1 through 4)							
Barium	Jan. 97	1/1	9.7	9.7	260/2,000	31.2	0
	April 97	1/1	11.8	11.8			0
	July 97	1/1	15.10	15.10			0
	Oct. 97	1/1	12.65	12.65			0
Cadmium	Jan. 97	0/1	NA	NA	1.8/5	NA	0
	April 97	1/1	0.35	0.35			0
	July 97	1/1	0.40	0.40			0
	Oct. 97	0/1	NA	NA			0
Calcium	Jan. 97	1/1	7,330	7,330	NL/NL	NA	NA
	April 97	1/1	6,950	6,950			NA
	July 97	1/1	6,585	6,585			NA
	Oct. 97	1/1	7,135	7,135			NA
Iron	Jan. 97	1/1	168	168	NL/NL	235	0
	April 97	1/1	244	244			1
	July 97	0/1	NA	NA			0
	Oct. 97	1/1	137.5	137.5			0
Lead	Jan. 97	0/1	NA	NA	NL/15	1.94	0
	April 97	1/1	1.4	1.4			0
	July 97	0/1	NA	NA			0
	Oct. 97	0/1	NA	NA			0
Magnesium	Jan. 97	1/1	498	498	NL/NL	NA	NA
	April 97	1/1	416	416			NA
	July 97	1/1	392	392			NA
	Oct. 97	1/1	408	408			NA
Manganese	Jan. 97	1/1	33.7	33.7	73/50	9.33	0
	April 97	1/1	17.7	17.7			0
	July 97	1/1	9.5	9.5			0
	Oct. 97	1/1	9.3	9.3			0
Potassium	Jan. 97	1/1	594	594	NL/NL	NA	NA
	April 97	0/1	NA	NA			NA
	July 97	0/1	NA	NA			NA
	Oct. 97	1/1	730.5	730.5			NA
Sodium	Jan. 97	1/1	1,940	1,940	NL/NL	NA	NA
	April 97	0/1	NA	NA			NA
	July 97	1/1	16,300	16,300			NA
	Oct. 97	0/1	NA	NA			NA

Notes:
NA = Not applicable/not available/not analyzed
NL = Not listed

Table 10.3.8
SWMU 163
Analytes Detected in Shallow Groundwater

Parameter	Location	1st Round	2nd Round	3rd Round	4th Round	5th Round	Tap-water RBC/ MCL	Shallow Background
Dioxin(pg/L)								
OCDD	163GW001	NT	**6.17**	NT	NT	NT	450/30	NA
Volatile Organic Compounds (μg/L)								
1,2-Dichloroethene (total)	163GWC02	NT	NT	NT	NT	2	5.5/70	NA
	163GWC03	NT	NT	NT	NT	**480**		
Tetrachloroethene	163GWC02	NT	NT	NT	NT	**2**	1.1/5	NA
	163GWC03	NT	NT	NT	NT	**47**		
Trichloroethene	163GWC03	NT	NT	NT	NT	**170**	1.6/5	NA
Semivolatile Organic Compounds (μg/L)								
Benzoic acid	163GW001	ND	ND	ND	6.5	ND	15,000/NL	NA
bis(2-Ethylhexyl)phthalate (BEHP)	163GWC02	NT	NT	NT	NT	**41**	4.8/6	NA
Butylbenzylphthalate	163GWC02	NT	NT	NT	NT	0.6	7,300/NL	NA
Di-n-butylphthalate	163GWC03	NT	NT	NT	NT	0.7	3,700/NL	NA
Inorganics (μg/L)								
Aluminum	163GW001	248	ND	ND	504	NT	3,700/NL	471
Arsenic	163GW001	**1.8**	ND	ND	ND	NT	0.045/50	NA
Barium	163GW001	9.7	11.75	15.1	12.65	NT	260/2,000	31.2
Cadmium	163GW001	ND	0.35	0.4	ND	NT	1.8/5	NA
Calcium	163GW001	7,330	6,950	6,585	7,135	NT	NL/NL	NA
Iron	163GW001	168	**244**	ND	137.5	NT	NL/NL	235
Lead	163GW001	ND	1.4	ND	ND	NT	NL/15	1.94
Magnesium	163GW001	498	466	392	408	NT	NL/NL	NA
Manganese	163GW001	33.7	17.7	9.5	9.3	NT	73/50	9.33
Potassium	163GW001	594	ND	ND	730.5	NT	NL/NL	NA
Sodium	163GW001	1,940	ND	16,300	ND	NT	NL/NL	NA

Notes:
NT = Not taken
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed
pg/L = Picograms per liter
μg/l = Micrograms per liter
Bolded concentrations exceed the lower of the RBC/MCL, and when available, the shallow groundwater background concentrations.



ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.3.3
VOCs IN SHALLOW GROUNDWATER
SWMU 163

Date: 05/27/99 | DWG Name: 2911C083

00149T072

Semivolatile Organic Compounds in Groundwater

Only one SVOC in groundwater samples exceeded an applicable RBC and/or MCL. BEPH (41 μg/L) was detected in the fifth-round samples from well 163GW002.

Pesticides/PCBs in Groundwater

No pesticides or PCBs were detected in the permanent monitoring well groundwater samples collected at SWMU 163.

Other Organic Compounds in Groundwater

A single dioxin compound (OCDD) was detected in the second-round groundwater sample collected at SWMU 163. This detection (6.17 pg/L) is three orders of magnitude lower than this dioxin compound's 450 pg/L RBC screening concentration.

Inorganics in Groundwater

Eleven inorganics were detected in groundwater samples collected at SWMU 163 during rounds one through four. Only arsenic and iron exceeded their applicable RBC/MCL and/or background screening concentrations. Single exceedance concentrations of both parameters were detected in well 163GW001. The arsenic exceedance (1.8 μg/L) occurred during round one; the iron exceedance (244 μg/L) occurred during round two.

10.3.5 Fate and Transport Assessment for SWMU 163

Environmental media sampled as part of the SWMU 163 RFI are surface soil, subsurface soil, and shallow groundwater. Potential constituent migration pathways investigated for SWMU 163 are soil to groundwater, risk-based groundwater migration, and emission of volatiles from surface soil-to-air.

10.3.5.1 SWMU 163 — Soil-to-Groundwater Cross-media Transport

Tables 10.3.9 and 10.3.10 compare maximum detected organic and inorganic concentrations in surface soil and subsurface soil samples to risk-based soil screening levels considered protective of groundwater. To provide a conservative screen, generic soil screening levels are used; leachate entering the aquifer is assumed to be diluted by a ratio of 10:1, with no attenuation of constituents in soil (DAF=10).

Two organic compounds in SWMU 163 soil exceeded above their groundwater protection SSLs: PCE and N-nitroso-di-n-propylamine .

PCE was detected in four of the five upper-interval soil samples and one of the five lower-interval samples. The groundwater protection screening level was exceeded at only one location (990 μg/kg in the upper-interval sample at 163SB003). The lower-interval PCE detection was also at the 163SB003 location, the only boring that was within the concrete pit, which had been placed in an area where cracks were apparent. PCE was also detected in groundwater above its RBC, therefore the pathway is considered valid at the SWMU.

N-nitroso-di-n-propylamine was detected in two SWMU 163 subsurface soil samples: 330 μg/kg at 163SB002 and 620 μg/kg at 163SB003. Both detections exceeded the groundwater protection screening level; however, the compound was not detected in the SWMU 163 groundwater sample. Of the two subsurface detections, the highest was under the base of the concrete pit. Due to its absence in groundwater, the pathway is considered invalid for this constituent.

Two inorganics — antimony and chromium — were detected in soil above their respective generic SSLs. The antimony exceedance (3.3 mg/kg) was in the upper-interval sample collected at 163SB002 and only slightly over the screening concentration (3 mg/kg). This was the only

Table 10.3.9
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap-water RBCs, and Soil to Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: SWMU 163
Charleston, South Carolina

	Maximum Concentration			Screening Concentration *							
Parameter	Surface Soil	Subsurfac Soil	Shallow GW	Soil to GW SSL	Tap Water RBC	Soil to Air SSL	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Volatilization Potential
Volatile Organic Compounds											
Acetone	2700	ND	ND	8000	3700	1E+08	UG/KG	UG/L	NO	NO	NO
Carbon disulfide	1	ND	ND	16000	1000	720000	UG/KG	UG/L	NO	NO	NO
1,2-Dichloroethene (total)	ND	ND	480	200 b	55	1200000	UG/KG	UG/L	NO	YES	NO
Tetrachloroethene (PCE) c	990	6	47	30	1.1	11000	UG/KG	UG/L	YES	YES	NO
Trichloroethene (TCE) c	22	ND	170	30	1.6	5000	UG/KG	UG/L	NO	YES	NO
Semivolatile Organic Compounds											
Acenaphthene	46	140	ND	290000	2200	NA	UG/KG	UG/L	NO	NO	NO
Acenaphthylene	88	ND	ND	47000 a	730	NA	UG/KG	UG/L	NO	NO	NO
Anthracene	65	220	ND	6000000	11000	NA	UG/KG	UG/L	NO	NO	NO
Benzoic acid	ND	ND	6.5	200000	150000	NA	UG/KG	UG/L	NO	NO	NO
Benzo(g,h,i)perylene	78	110	ND	5.7E+07 a	730	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)pyrene equivalents (BEQs) c	390	312	ND	NA	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)anthracene c	280	300	ND	800	0.092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)pyrene c	180	230	ND	4000	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(b)fluoranthene c	190	210	ND	2300 a	0.092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(k)fluoranthene c	180	200	ND	25000	0.92	NA	UG/KG	UG/L	NO	NO	NO
Chrysene c	400	290	ND	80000	9.2	NA	UG/KG	UG/L	NO	NO	NO
Dibenzo(a,h)anthracene c	150	ND	ND	800	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Indeno(1,2,3-cd)pyrene c	230	290	ND	7000	0.092	NA	UG/KG	UG/L	NO	NO	NO
Butylbenzylphthalate c	160	ND	0.6	930000	7300	930000	UG/KG	UG/L	NO	NO	NO
Dibenzofuran	54	75	ND	6800 a	24	120000	UG/KG	UG/L	NO	NO	NO
Di-n-butylphthalate	39	ND	0.7	2300000	3700	2300000	UG/KG	UG/L	NO	NO	NO
bis(2-Ethylhexyl)phthalate (BEHP) c	440	ND	41	1800000	4.8	3.1E+07	UG/KG	UG/L	NO	YES	NO
Fluoranthene	600	740	ND	2100000	1500	NA	UG/KG	UG/L	NO	NO	NO
Fluorene	42	98	ND	280000	1500	NA	UG/KG	UG/L	NO	NO	NO
2-Methylnaphthalene	280	ND	ND	18000 a	120	NA	UG/KG	UG/L	NO	NO	NO
Naphthalene	140	ND	ND	31000 a	730	NA	UG/KG	UG/L	NO	NO	NO
N-Nitroso-di-n-propylamine c	ND	620	ND	0.024 a	0.0096	NA	UG/KG	UG/L	YES	NO	NO
Phenanthrene	210	760	ND	660000 a	1100	NA	UG/KG	UG/L	NO	NO	NO
Phenol	240	300	ND	50000	22000	NA	UG/KG	UG/L	NO	NO	NO
Pyrene	400	480	ND	2100000	1100	NA	UG/KG	UG/L	NO	NO	NO
Pesticides/PCB Compounds											
4,4'-DDD c	8.21	ND	ND	8000	0.28	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDE c	53.3	ND	ND	27000	0.2	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDT c	55.3	ND	ND	16000	0.2	1.0E+09	UG/KG	UG/L	NO	NO	NO
Dioxin Compounds											
2378-TCDD Equivalents (TEQs) c	0.067	NA	0.00617	1600 a	0.45	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDD c	1.76	NA	ND	110000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDD c	19.8	NA	6.17	1100000 a	450	NA	NG/KG	PG/L	NO	NO	NO
234678-HxCDF c	0.24	NA	ND	220000 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDF c	0.58	NA	ND	54000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDF c	0.692	NA	ND	540000 a	450	NA	NG/KG	PG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.6
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.3.2 and 10.3.6.

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Based on surrogate compound (See Table 5.6)
c - Carcinogen
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration

SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.3.10
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, Soil to Air SSLs, and Background Reference Values
Charleston Naval Complex, Zone K, Naval Annex: SWMU 163
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurface Soil	Shallow GW	Screening Concentration Soil to GW SSL	Soil Background Reference	Soil to Air SSL	Tap Water RBC	GW Background Reference	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Fugitive Particulate Inhalation Concern
Inorganics													
Aluminum	10000	6690	504	560000 a	11200	NA	37000	471	MG/KG	UG/L	NO	NO	NO
Antimony	3.3	ND	ND	2.7	0.45	NA	15	NA	MG/KG	UG/L	YES	NO	NO
Arsenic c	3.3	1.8	1.8	15	3	750	0.045	NA	MG/KG	UG/L	NO	YES	NO
Barium	49.4	6.9	15.1	820	25.6	690000	2600	31.2	MG/KG	UG/L	NO	NO	NO
Beryllium	0.27	ND	ND	32	0.17	1300	73	NA	MG/KG	UG/L	NO	NO	NO
Cadmium	1	ND	0.4	3.8	0.13	1800	18	NA	MG/KG	UG/L	NO	NO	NO
Chromium (total)	21.5	8.4	ND	19 b	8.76	270	110	NA	MG/KG	UG/L	YES	NO	NO
Cobalt	5.4	1.3	ND	990 a	0.62	NA	2200	NA	MG/KG	UG/L	NO	NO	NO
Copper	14.4	ND	ND	5600 a	3.86	NA	1500	2.8	MG/KG	UG/L	NO	NO	NO
Lead	149	4.1	1.4	400 d	39.6	400	15	1.9	MG/KG	UG/L	NO	NO	NO
Manganese	33.9	12.8	33.7	480 a	26.4	NA	730	9.3	MG/KG	UG/L	NO	NO	NO
Mercury	0.07	ND	ND	1	NA	10	11	NA	MG/KG	UG/L	NO	NO	NO
Nickel	4.7	2.3	ND	65	2.64	13000	730	NA	MG/KG	UG/L	NO	NO	NO
Selenium	0.56	ND	ND	2.6	0.84	NA	180	NA	MG/KG	UG/L	NO	NO	NO
Vanadium	13.8	6.6	ND	3000	15.8	NA	260	0.8	MG/KG	UG/L	NO	NO	NO
Zinc	268	18.1	ND	6200	14.8	NA	11000	NA	MG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.7
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.3.3 and 10.3.7.

Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Assumes hexachrome
c - Carcinogen
d - USEPA de facto residential soil level
GW - Groundwater
NA - Not available/Not applicable

ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

detection of antimony in soil at SWMU 163. Antimony was not detected in groundwater samples collected at SWMU 163.

The only chromium exceedance in soil was also in the upper-interval sample collected at 163SB002. This concentration (21.5 mg/kg) also only slightly exceeded the screening concentration (19 mg/kg). The generic SSL for total chromium assumes that all detected chromium is the more toxic hexavalent variety, but no hexachrome was detected in any of the 11 Naval Annex soil samples (including one sample at SWMU 163) where it was one of the analytical parameters. Chromium was not detected in groundwater samples collected at SWMU 163.

10.3.5.2 SWMU 163 — Risk-Based Groundwater Transport

Table 10.3.9 and 10.3.10 also compare maximum detected organic and inorganic concentrations in shallow groundwater samples to risk-based concentrations for drinking water. To provide a conservative screen, no attenuation or dilution of constituents in groundwater is assumed before comparison to the relevant standards. It should be noted that this screening is done for evaluation only; the pathway is inherently invalid due to non-use of the resource as a potable water source.

Four organics - 1,2 DCE, PCE, TCE, and BEHP - were present in groundwater above their respective RBCs. The highest concentrations of chlorinated organics were from one location (163GWC03) and the BEHP exceedance was from location 163GWC02. The presence of these compounds in groundwater could prove significant if the pathway were valid, but the spatial lack of persistence also points to a small affected groundwater mass. Given that these were not analyzed for until the fifth round; additional sampling is required to demonstrate temporal persistence and significance.

Arsenic (first-quarter only) and iron (second-quarter only) exceeded their respective RBCs. Concentrations of these have been non-detect to below screening levels in subsequent quarters, thus the pathway for them is considered invalid.

10.3.5.3 SWMU 163 — Soil-to-air Cross-media Transport

No VOCs were detected in SWMU 163 surface soil samples. As a result, the soil-to-air migration pathway is not expected to be significant at SWMU 163.

10.3.5.4 SWMU 163 — Fate and Transport Summary

Two organics and two inorganics detected in SWMU 163 soil exceeded groundwater protection screening levels. Except for N-nitroso-di-n-propylamine, all exceedances were in upper-interval soil samples. This organic was detected in only two of 10 total soil samples. PCE, which was above screening in soil, was also above the RBC in groundwater, thereby validating the soil-to-groundwater pathway for this parameter.

Four organics and two inorganics exceeded their RBCs in groundwater. Due to non-use of the resource, this pathway is considered inherently invalid. The bulk of organic exceedance were from one location; the inorganics have been non-detected or below RBCs since at least the second-quarter. Further sampling is required to determine spatial and temporal persistence and significance of these exceedances.

No other fate and transport concerns were identified at SWMU 163.

10.3.6 Human Health Risk Assessment for SWMU 163

10.3.6.1 Site Background and Investigative Approach

SWMU 163 is a former less-than-90-day accumulation area for hazardous waste generated at the Naval Annex. The site consists of a 100 square-foot concrete pit north of Building 2513. Materials of concern due to past site operations are solvents, paint wastes, and heavy metals.

Ten soil samples were collected from each of the upper and lower-intervals to identify potential impacts from the activities listed above. Surface soil samples from all 10 boring locations were used to quantitatively assess soil exposure pathways. Subsurface soil is addressed in the previous section. Three monitoring wells were installed in the shallow aquifer. Data from the four-quarterly sampling events were used to quantitatively assess groundwater exposure pathways. Sections 10.3.1 and 10.3.3 summarize the sampling effort for SWMU 163 soil and groundwater.

10.3.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this report and presented in Table 10.3.11, benzo(a)pyrene equivalent compounds, arsenic, antimony, and were identified as COPCs in surface soil. Wilcoxon rank sum test analysis resulted in the inclusion of aluminum on the basis of background concentration comparison.

Groundwater

As shown in Table 10.3.12, arsenic, bis(2-ethylhexyl)phthalate, 1,2-dichloroethene, tetrachloroethene, and trichloroethene were identified as a COPCs for shallow groundwater at SWMU 163. Wilcoxon rank sum test analysis did not result in the inclusion of any parameter that had been screened out on the basis of background concentration comparison.

Table 10.3.11
Chemicals Present in Site Samples
SWMU 163 - Surface Soil
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
Carcinogenic PAHs													
B(a)P Equiv.	*	6	10	15	389.6	104	360	380	87	NA	UG/KG	2	
Benzo(a)anthracene		3	10	39	280	160	360	380	870	NA	UG/KG		
Benzo(a)pyrene	*	3	10	37	180	100	360	380	87	NA	UG/KG	1	
Benzo(k)fluoranthene		3	10	56	180	125	360	380	8700	NA	UG/KG		
Chrysene		5	10	43	400	148	360	380	87000	NA	UG/KG		
Benzo(b)fluoranthene		4	10	52	190	90.25	360	380	870	NA	UG/KG		
Dibenz(a,h)anthracene	*	1	10	150	150	150	340	380	87	NA	UG/KG	1	
Indeno(1,2,3-cd) pyrene		5	10	150	230	172	360	380	870	NA	UG/KG		
TCDD Equivalents													
1234678-HpCDD		1	1	1.76	1.76	1.76	NA	NA	NA	NA	NG/KG		
1234678-HpCDF		1	1	0.58	0.58	0.58	NA	NA	NA	NA	NG/KG		
234678-HxCDF		1	1	0.24	0.24	0.24	NA	NA	NA	NA	NG/KG		
Dioxin Equiv.		1	1	0.0679	0.0679	0.0679	NA	NA	1000[b]	NA	NG/KG		
OCDD		1	1	19.8	19.8	19.8	NA	NA	NA	NA	NG/KG		
OCDF		1	1	0.692	0.692	0.692	NA	NA	NA	NA	NG/KG		
Inorganics													
Aluminum (Al)		5	5	5210	10000	7884	NA	NA	7800	11200	MG/KG	3	
Antimony (Sb)	*	1	5	3.3	3.3	3.3	0.35	0.4	3.1	0.45	MG/KG	1	1
Arsenic (As)	*	5	5	1.2	3.3	2.15	NA	NA	0.43	3	MG/KG	5	1
Barium (Ba)		5	5	13.75	49.4	25.47	NA	NA	550	25.6	MG/KG		1
Beryllium (Be)		1	5	0.27	0.27	0.27	0.02	0.12	16	0.17	MG/KG		1
Cadmium (Cd)		3	5	0.53	1	0.7533	0.07	0.12	3.9	0.13	MG/KG		3
Calcium (Ca)		5	5	870	5180	3028.1	NA	NA	NA	NA	MG/KG		
Chromium (Cr)		5	5	5.6	21.5	12.43	NA	NA	23	8.4	MG/KG		3
Cobalt (Co)		5	5	0.5	5.4	2.012	NA	NA	470	0.34	MG/KG		5
Copper (Cu)		3	5	4.2	14.4	7.7	0.42	2.1	310	3.86	MG/KG		3
Iron (Fe)		5	5	2820	5430	4076	NA	NA	2300	7060	MG/KG	5	
Lead (Pb)		5	5	8.55	149	48.93	NA	NA	400	39.6	MG/KG		2
Magnesium (Mg)		5	5	72.6	324	240.32	NA	NA	NA	NA	MG/KG		
Manganese (Mn)	a	5	5	4.6	33.9	17.85	NA	NA	1100	26.4	MG/KG		2
Mercury (Hg)		1	5	0.07	0.07	0.07	0.05	0.06	2.3	NA	MG/KG		
Nickel (Ni)		5	5	1.6	4.7	2.87	NA	NA	160	1.7	MG/KG		4
Potassium (K)		5	5	53	144	114.2	NA	NA	NA	NA	MG/KG		
Selenium (Se)		2	5	0.5	0.56	0.53	0.37	0.42	39	0.84	MG/KG		
Sodium (Na)		4	5	49.65	96.8	68.4375	14.7	14.7	NA	NA	MG/KG		
Vanadium (V)		5	5	7.9	13.8	11.51	NA	NA	55	15.8	MG/KG		
Zinc (Zn)		5	5	10.65	268	90.89	NA	NA	2300	14.8	MG/KG		4
Pesticides													
4,4'-DDD		2	5	6.59	8.21	7.4	3.62	19.3	2700	NA	UG/KG		
4,4'-DDE		3	5	5.1	53.3	21.8067	3.63	19.3	1900	NA	UG/KG		
4,4'-DDT		3	5	9.12	55.3	29.9067	3.63	19.3	1900	NA	UG/KG		
Semivolatile Organics													
Acenaphthene		1	10	46	46	46	340	380	470000	NA	UG/KG		
Acenaphthylene		1	10	88	88	88	340	380	160000	NA	UG/KG		
Anthracene		1	9	65	65	65	340	380	2300000	NA	UG/KG		
Benzo(g,h,i)perylene		1	10	78	78	78	340	380	160000	NA	UG/KG		
Bis(2-Ethylhexyl)phthalate		3	10	41	440	179	360	380	46000	NA	UG/KG		
Butylbenzylphthalate		1	10	160	160	160	360	380	1600000	NA	UG/KG		
Dibenzofuran		1	10	54	54	54	340	380	31000	NA	UG/KG		
Di-n-butylphthalate		1	9	39	39	39	360	380	780000	NA	UG/KG		
Fluoranthene		5	10	53	600	226.4	360	380	310000	NA	UG/KG		
Fluorene		1	10	42	42	42	340	380	310000	NA	UG/KG		
Naphthalene		1	10	140	140	140	340	380	160000	NA	UG/KG		
Phenanthrene		2	9	150	210	180	340	380	160000	NA	UG/KG		
Phenol		2	10	120	240	180	340	380	4700000	NA	UG/KG		
Pyrene		5	10	54	400	171	360	380	230000	NA	UG/KG		
2-Methylnaphthalene		1	10	280	280	280	340	380	160000	NA	UG/KG		
Volatile Organics													
Acetone		1	10	2700	2700	2700	5	12	780000	NA	UG/KG		
Carbon Disulfide		1	10	1	1	1	5	6	780000	NA	UG/KG		
Tetrachloroethene		4	10	14	990	262	5	6	12000	NA	UG/KG		
Trichloroethene		3	5	5	22	11	5	6	58000	NA	UG/KG		

Notes:
* - Indicates chemical was identified as a COPC
a - The food RBC was used as a screening value for concentrations of manganese in soil
b - Reported soil concentrations of dioxin (as TEQs) were compared to the project screening level.
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/KG - micrograms per kilogram
MG/KG - milligrams per kilogram
NA - Not applicable or not available

Reported soil concentrations of managanese were compared to the RBC associated with food exposures

Table 10.3.12
Chemicals Present in Site Samples
SWMU 163 - Groundwater
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
Volatile Organic Compounds													
1,2-Dichloroethene (total)	*	2	2	2	480	241	NA	NA	5.5	NA	UG/L	1	
Tetrachloroethene	*	2	6	2	47	24.5	5	5	1.1	NA	UG/L	2	
Trichloroethene	*	1	6	170	170	170	5	5	1.6	NA	UG/L	1	
Semivolatile Organic Compounds													
Benzoic Acid		1	6	6.5	6.5	6.5	25	62	15000	NA	UG/L		
Bis(2-Ethylhexyl)phthalate	*	1	6	41	41	41	10	12	4.8	NA	UG/L	1	
Butylbenzylphthalate		1	6	0.6	0.6	0.6	10	12	7300	NA	UG/L		
Di-n-butylphthalate		1	6	0.7	0.7	0.7	10	12	370	NA	UG/L		
Dioxins													
OCDD		1	1	6.17	6.17	6.17	NA	NA	NA	NA	PG/L		
Dioxin eqivalents		1	1	0.0062	0.0062	0.00617	NA	NA	0.45	NA	PG/L		
Inorganics													
Aluminum (Al)	*	2	4	248	504	376	437	463	3700	NA	UG/L		
Arsenic (As)	*	1	4	1.8	1.8	1.8	1.8	3	0.045	NA	UG/L	1	
Barium (Ba)		4	4	9.7	15.1	12.3	NA	NA	260	31.4	UG/L		
Cadmium		2	4	0.35	0.4	0.375	0.42	1.0	1.8	NA	UG/L		
Calcium (Ca)		4	4	6585	7330	7000	NA	NA	NA	NA	UG/L		
Iron (Fe)		3	4	137.5	244	183	76	76	1100	235	UG/L		1
Lead		1	4	1.4	1.4	1.4	0.89	1.9	15	NA	UG/L		
Magnesium (Mg)		4	4	392	498	441	NA	NA	NA	NA	UG/L		
Manganese (Mn)		4	4	9.3	33.7	17.6	NA	NA	73	15.5	UG/L		2
Potassium (K)		2	4	594	730.5	662	559	913	NA	NA	UG/L		
Sodium (Na)		2	4	1940	16300	9120	1930	9000	NA	NA	UG/L		

Notes:
* - Indicates chemical was identified as a COPC
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/L - micrograms per liter
NA - Not applicable or not available

10.3.6.3 Exposure Assessment

Exposure Setting

SWMU 163 is located approximately 100 feet north of Building 2513 at the Naval Annex. The site consists of a 100-square-foot concrete pit, 2 feet deep. All potable water is provided through the city's water supply. Shallow groundwater at the site is not currently used as potable or process water nor is it anticipated to be used for this purpose in the future.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents and adolescent trespassers. Future site resident and worker exposure scenarios were addressed quantitatively in this risk assessment.

Current exposure to workers is discussed qualitatively in relation to the future workers and future residents. The hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact (the concrete surfacing would prevent direct contact to a portion of the site). Therefore, future worker assessment is considered to be conservatively representative of current site workers. The adolescent trespasser was qualitatively addressed relative to the child resident. The future site resident scenario was built on the premise that existing features would be replaced with dwellings.

Exposure Pathways

Exposure pathways for the hypothetical future site residents are dermal contact and incidental ingestion of surface soils. The exposure pathways for future site workers are the same as those for the future site residents with respect to soil. The groundwater pathway for the hypothetical future site residents is incidental ingestion of groundwater and inhalation of volatiles resulting from domestic or process use of groundwater. Uniform exposure was assumed for all sample locations. Table 10.3.13 presents the justification for exposure pathways assessed in this HHRA.

Table 10.3.13
Exposure Pathways Summary - SWMU 163
Charleston Naval Complex - Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Users (Site Workers)	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or process water at SWMU 163.
	Shallow groundwater, inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or process water at SWMU 163.
	Soil, incidental ingestion	No (Qualified)	Future site use is considered conservatively representative of current receptors.
	Soil, dermal contact	No (Qualified)	Future site use is considered conservatively representative of current receptors.
Future Land Uses			
Future Site Residents (Child and Adult), Future Site Worker	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	Yes	Shallow groundwater is not likely to be used as a source of potable or nonresidential water at SWMU 163. This pathway was addressed as a conservative measure.
	Shallow groundwater, inhalation of volatilized contaminants during domestic use	Yes	Shallow groundwater is not likely to be used as a source of potable or nonresidential water at SWMU 163. This pathway was addressed as a conservative measure.
	Soil, incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, city limits.
	Fruits and vegetables, ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

Because fewer than 10 surface soil samples were analyzed for inorganics, maximum detected concentrations for aluminum, antimony, and arsenic were used as exposure point concentrations, as discussed in Section 7 of this RFI. Ten surface soil samples were analyzed for benzo(a)pyrene equivalents. Because the 95% UCL for benzo(a)pyrene equivalents exceeded its maximum concentration, the maximum detected concentration was used as the EPC. Because fewer than 10 shallow groundwater samples were collected, maximum detected concentrations were used as the EPC.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soils are shown in Tables 10.3.14 and 10.3.15, respectively.

Groundwater

CDIs for the groundwater pathway are shown in Table 10.3.16. They apply to both ingestion and inhalation pathways.

10.3.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.3.17 presents toxicological information specific to each COPC identified at SWMU 163. This information was used in the quantification of risk/hazard associated with soil contaminants. Each COPC's toxicology is briefly profiled in the following paragraphs.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. The metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other

Table 10.3.14
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganics							
Antimony (Sb)	1	3.3	4.5E-06	4.2E-05	5.2E-06	1.6E-06	5.8E-07
Arsenic (As)	1	3.3	4.5E-06	4.2E-05	5.2E-06	1.6E-06	5.8E-07
Aluminum (Al)	1	10000	1.4E-02	1.3E-01	1.6E-02	4.9E-03	1.7E-03
Semivolatile Organics							
Benzo(a)pyrene equivalent	1	0.3896	5.3E-07	5.0E-06	6.1E-07	1.9E-07	6.8E-08

NOTES:

LWA	Lifetime-weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.3.15
Chronic Daily Intakes (CDI)
Dermal Contact with Surface Soil
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	FI/FC *	Exposure Point Concentration (mg/kg)	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganics								
Antimony (Sb)	1	3.3	0.001	1.9E-07	6.1E-07	1.2E-07	1.3E-07	4.7E-08
Arsenic (As)	1	3.3	0.001	1.9E-07	6.1E-07	1.2E-07	1.3E-07	4.7E-08
Aluminum (Al)	1	10000	0.001	5.6E-04	1.9E-03	3.5E-04	4.0E-04	1.4E-04
Semivolatile Organics								
Benzo(a)pyrene equivalents	1	0.3896	0.01	2.2E-07	7.2E-07	1.4E-07	1.6E-07	5.6E-08

NOTES:
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.
\- The dermal absorption factor was applied to the exposure point concentration
to reflect the ability for trans-dermal migration of inorganic and organic chemicals

Table 10.3.16
Chronic Daily Intakes (CDI)
Ingestion of COPCs in Shallow Groundwater
SWMU 163
Charleston Naval Complex, Zone K
Charleston, SC

Chemical	Exposure Point Concentration (mg/liter)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Arsenic	0.0018	4.93E-05	1.15E-04	2.71E-05	1.76E-05	6.29E-06
bis(2-Ethylhexyl)phthalate	0.041	1.12E-03	2.62E-03	6.18E-04	4.01E-04	1.43E-04
1,2-Dichloroethene	0.48	1.32E-02	3.07E-02	7.23E-03	4.70E-03	1.68E-03
Tetrachloroethene	0.047	1.29E-03	3.00E-03	7.08E-04	4.60E-04	1.64E-04
Trichloroethene	0.17	4.66E-03	1.09E-02	2.56E-03	1.66E-03	5.94E-04

NOTES:

LWA	Lifetime-weighted average
CDI	Chronic Daily Intake
H-CDI	Non-carcinogenic hazard based Chronic Daily Intake
C-CDI	Carcinogenic risk based Chronic Daily Intake

Table 10.3.17
Toxicological Reference Information
for Chemicals of Potential Concern
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

	Non-Carcinogenic Toxicity Data									*Carcinogenic Toxicity Data*					
Chemical	Oral Reference Dose (mg/kg-day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg-day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation	Oral Slope Factor (kg-day/mg)		Inhalation Slope Factor (kg-day/mg)		Weight of Evidence	Tumor Type
Aluminum	1	d	NA	NA	NA	NA	NA	NA	NA	NA		NA		NA	NA
Antimony	0.0004	a	L	whole body/blood increased mortality	1,000	NA	NA	NA	NA	NA		NA		D	NA
Arsenic	0.0003	a	M	hyperpigmentation	3	NA	NA	NA	NA	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	NA		NA	NA	NA	NA	NA	NA	NA	7.3	a	6.1	b	B2	mutagen
bis(2-Ethylhexyl)phthalate	0.02	a	M	increased liver weight	1,000	NA	NA	NA	NA	0.014	a	NA		B2	hepatoma
1,2-Dichloroethene (total)	0.009	b	L	increased serum phosphatase	1,000	NA	NA	NA	NA	NA		NA		D	NA
Tetrachloroethene	0.01	a	M/L	hepatotoxicity in mice, weight gain in rats	1,000	NA	NA	NA	NA	0.052	d	0.002	d	NA	NA
Trichloroethene	0.006	e	NA	NA	NA	NA	NA	NA	NA	0.011		0.006	e	B2	forestomach tumor

Notes:

a = Integrated Risk Information System (IRIS)
b = Withdrawn from IRIS/HEAST
d = EPA-National Center for Environemtnal Assessment Cincinnati (Provisional).
D = Carcinogenic potential not classifiable
A = Known human carcinogen
B2 = Possible human carcinogen based on laboratory animal study data.
NA = Not applicable or not available
L = Low confidence
M = Medium confidence

elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuromuscular system controlling bowel muscles. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaasen, et al., 1986; Dreisbach et al., 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg/day. The aesthetic-based secondary MCL for drinking water is 50 to 200 μg/L.

Antimony belongs to the same periodic group as arsenic. This element is absorbed slowly through the gastrointestinal tract, which is its target. Another target is the blood, where antimony concentrates. Due to frequent industrial use, the primary exposure route for antimony to the general population is food. Antimony is also a common air pollutant from industrial emissions (Klaassen, et al, 1986). USEPA has not classified antimony as a carcinogen, and the oral RfD is 0.0004 mg/kg-day.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.0003 mg/kg/day as the RfD for arsenic. As listed in IRIS, the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg/day)^{-1}$ SF. As listed in IRIS, the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic.

Benzo(a)pyrene equivalents include the following list of polynuclear aromatic hydrocarbons:

	TEF
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Dibenz(a,h)anthracene	1.0
Benzo(k)fluoranthene	0.01
Benzo(a)pyrene	1.0
Indeno(1,2,3-cd)pyrene	0.1
Chrysene	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. They have no RfDs due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF of 7.3 $(mg/kg/day)^{-1}$. Toxicity equivalency factors, also set by USEPA, are multipliers applied to the detected concentrations and subsequently used to calculate excess cancer risk. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS, the basis for the benzo(a)pyrene B2 classification is animal studies. Human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

bis(2-Ethylhexyl)phthalate, otherwise known as BEHP, is a plasticizer used in virtually every major product category. Phthalate esters are ubiquitously in the environment. Although the toxicity of this compound is relatively low, it is a carcinogen. Reproductive effects are also possible (indicated in animal studies) due to chronic exposure to BEHP. This compound is classified as a B2 carcinogen, and USEPA set the oral RfD and oral SF to 0.02 mg/kg-day and 0.014 $(mg/kg\text{-}day)^{-1}$, respectively (Klaassen et al., 1986).

1,2-Dichloroethene is a halogenated hydrocarbon associated with toxicity to the mucous membrane, skin, lung, cornea (irritation), and liver. This compound is less toxic than its alkane counterparts, and is neither mutagenic nor carcinogenic. There is no USEPA carcinogenicity listing for this compound (Dreisbach et al., 1987). However, the oral RfD has been set to 1E-02 mg/kg-day for the cis-isomer, and at 2E-02 mg/kg/day for the trans-isomer by USEPA.

Tetrachloroethene (PCE) has been used as a solvent in industry and occurs as a volatile constituent in other chlorinated hydrocarbons. Tetrachloroethene exposure can result in long-lasting narcosis with delayed onset and damage to the liver and kidneys. The principal manifestations of overexposure to this halogenated hydrocarbon are irritation of the eyes and nose followed by headache and nausea as well as coma, jaundice, and oliguria. Cyanosis and CNS depression progressing to coma appear one to four hours after the short-term exposure. Liver and kidney damage after apparent recovery or after repeated exposures cause acute symptoms as nausea, vomiting, abdominal pain, jaundice, oliguria, and uremia. PCE exposure via the inhalation and/or skin absorption exposure pathways could result in headache, tremor, dizziness, peripheral paresthesia, hypesthesia, or anesthesia. PCE is a carcinogen, but is currently under review by USEPA; it is currently classified as a B2-C carcinogen. The oral RfD has been set to 0.01 mg/kg-day, and the oral SF and inhalation SF have been set to 0.052 and 0.0023 $(mg/kg\text{-}day)^{-1}$, respectively, by USEPA (Dreisbach et al., 1987). An oral RfD uncertainty factor of 1000 has been issued for PCE as well as a modifying factor of 1.

Trichloroethene is a mobile, volatile liquid with the characteristic odor of chloroform. Inhalation, intravenous, and subcutaneous routes are all viable exposure pathways for this compound. TCE is a strong skin and eye irritant that is relatively less toxic if ingested. Inhaling high concentrations causes narcosis and anesthesia. This compound targets the liver and other organs (Dreisbach et al., 1987). TCE is a B2 carcinogen, and the oral SF and inhalation SF have been set by USEPA to 0.011 and 0.006 $(mg/kg\text{-}day)^{-1}$, respectively. USEPA also set the oral RfD to 0.006 mg/kg-day.

10.3.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under residential and industrial (site worker) scenarios using the incidental ingestion and dermal contact exposure pathways. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.3.18 and 10.3.19 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of site surface soils, and dermal contact with them.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime-weighted average) for SWMU 163 surface soils is 1E-5. The dermal pathway ILCR is 3E-6. Arsenic and benzo(a)pyrene equivalents were the primary contributors to ILCR projections for the ingestion and dermal pathways.

The ingestion HIs projected for the adult and child receptors are 0.04 and 0.37, respectively. The dermal pathway HIs were 0.008 for the adult resident receptor and 0.03 for the child resident receptor.

Table 10.3.18
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganics							
Antimony (Sb)	0.0004	NA	0.011	0.11	ND	0.0040	ND
Arsenic (As)	0.0003	1.5	0.015	0.14	7.7E-06	0.0054	8.6E-07
Aluminum (Al)	1	NA	0.014	0.13	ND	0.0049	ND
Semivolatile Organics							
Benzo(a)pyrene equivalents	NA	7.3	ND	ND	4.5E-06	ND	5.0E-07
SUM Hazard Index/ILCR			0.040	0.37	1E-05	0.014	1E-06

NOTES:
- NA Not applicable
- ND Not Determined due to lack of available information
- LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
- ILCR Incremental Lifetime Cancer Risk

Table 10.3.19
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganics								
Antimony (Sb)	0.2	0.00008	NA	0.0023	0.0076	ND	0.0017	ND
Arsenic (As)	0.2	0.00006	7.5	0.0031	0.010	8.7E-07	0.0022	3.5E-07
Aluminum (Al)	0.2	0.20	NA	0.0028	0.0093	ND	0.0020	ND
Semivolatile Organics								
Benzo(a)pyrene equivalents	0.5	NA	14.6	ND	ND	2.0E-06	ND	8.1E-07
SUM Hazard Index/ILCR				0.0082	0.027	3E-06	0.0059	1E-06

NOTES:

NA Not applicable
ND Not Determined due to lack of available information
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Hypothetical Site Workers

Site worker ILCRs are 1E-6 for the ingestion pathway and 1E-06 for the dermal contact pathway. Benzo(a)pyrene equivalents and arsenic combined for a cumulative risk exceeding 1E-06, although none individually exceeded 1E-06.

Site worker HIs are 0.01 for the ingestion pathway and 0.006 for the dermal pathway.

Groundwater Pathways

Exposure to shallow onsite groundwater was evaluated under both a residential and industrial scenario based on the results of the four quarterly sampling events. The ingestion and inhalation exposure pathways were evaluated assuming that the site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately for child and adult receptors. Tables 10.3.20 and 10.3.21 presents the risk and hazard for the ingestion and inhalation exposure pathways, respectively.

Hypothetical Site Residents

The shallow groundwater ingestion ILCR for hypothetical site residents is IE-04, and the inhalation pathway ILCR is 2E-05. For the ingestion pathway, arsenic, bis(2-ethylhexyl)phthalate, tetrachloroethene, and trichloroethene are the primary contributors to ILCR. Tetrachloroethene and trichloroethene contribute to the ILCR for the inhalation pathway. For the ingestion pathway, the hazard indices for the adult and child resident are 3 and 6, respectively. Inhalation pathway hazard indices were 2 and 5 for the adult and child resident, respectively. The primary contributors to hazard index projections for groundwater pathways are 1,2-dichloroethene and trichloroethene.

Table 10.3.20
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
SWMU 163
Charleston Naval Complex - Zone K
Charleston, SC

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident LWA ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Arsenic	0.0003	1.5	0.16	0.38	4.1E-05	0.059	9.4E-06
bis(2-Ethylhexyl)phthalate	0.02	0.014	0.056	0.13	8.6E-06	0.020	2.0E-06
1,2-Dichloroethene	0.009	NA	1.5	3.4	ND	0.52	ND
Tetrachloroethene	0.01	0.052	0.13	0.30	3.7E-05	0.046	8.5E-06
Trichloroethene	0.006	0.011	0.78	1.8	2.8E-05	0.28	6.5E-06
SUM Hazard Index/ILCR			3	6	1E-04	0.9	3E-05

NOTES:

NA Not available
ND Not Determined due to lack of available information
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk

Table 10.3.21
Hazard Quotients and Incremental Lifetime Cancer Risks
Inhalation of Volatiles in Groundwater
SWMU 163
Charleston Naval Complex - Zone K
Charleston, SC

Chemical	Inhalation RfD Used (mg/kg-day)	Inhalation SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident LWA ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
1,2-Dichloroethene	0.009	NA	1.5	3.4	ND	0.52	ND
Tetrachloroethene	0.14	0.002	0.0092	0.021	1.4E-06	0.0033	3.3E-07
Trichloroethene	0.006	0.006	0.78	1.8	1.5E-05	0.28	3.6E-06
SUM Hazard Index/ILCR			2	5	2E-05	0.8	4E-06

NOTES:
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime excess Cancer Risk
NA Not available
ND Not Determined due to lack of available information

Hypothetical Site Workers

The shallow groundwater pathway risk for the site worker scenario is 3E-05 and 4E-06 for the ingestion and inhalation pathways, respectively. For the ingestion pathway, arsenic, bis(2-ethylhexyl)phthalate, tetrachlororethene, and trichlororethene contributed to risk projections. Tetrachloroethene and trichloroethene contributed to the ILCR for the inhalation pathway. For the ingestion and inhalation pathways, the hazard indices for the adult worker are 0.9 and 0.8, respectively.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for SWMU 163 or other Zone K areas. In the absence of a completed exposure pathway, reported shallow groundwater quality poses no threat to human health.

COCs Identified

Chemicals of concern were identified based on cumulative (all pathway) risk and hazard projected for this site on a medium-specific basis. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). In this HHRA, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index exceeding 1.0, if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to more comprehensively evaluate chemicals contributing to carcinogenic risk or noncarcinogenic hazard during remedial goal options development. Table 10.3.22 presents the COCs identified for SWMU 163 surface soil and groundwater.

Table 10.3.22
Summary of Risk and Hazard-based COCs
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient (HI)	Future Resident Child Hazard Quotient (HI)	Future Resident LWA ILCR	Current Site Worker Hazard Quotient	Current Site Worker ILCR	Identification of COCs
Surface Soil	Incidental Ingestion	**Inorganics**						
		Antimony (Sb)	0.011	0.11	ND	0.0040	ND	
		Arsenic (As)	0.015	0.14	7.7E-06	0.0054	8.6E-07	2
		Aluminum (Al)	0.014	0.13	ND	0.0049	ND	
		Semivolatile Organics						
		Benzo(a)pyrene equivalents	ND	ND	4.5E-06	ND	5.0E-07	2
	Dermal	**Inorganics**						
		Antimony (Sb)	0.0023	0.0076	ND	0.0017	ND	
		Arsenic (As)	0.0031	0.010	8.7E-07	0.0022	3.5E-07	
		Aluminum (Al)	0.0028	0.0093	ND	0.0020	ND	
		Semivolatile Organics						
		Benzo(a)pyrene equivalents	ND	ND	2.0E-06	ND	8.1E-07	2
Surface Soil Pathway Sum			0.05	0.4	2E-05	0.02	3E-06	
Groundwater Pathways	Ingestion	**Inorganics**						
		Arsenic (As)	0.16	0.38	4.1E-05	0.059	9.4E-06	1 2 4
		Semivolatile Organics						
		Aluminum (Al)	0.056	0.13	8.6E-06	0.020	2.0E-06	1 2 4
		Volatile Organics						
		0	1.5	3.4	ND	0.52	ND	1 3
		Semivolatile Organics	0.13	0.30	3.7E-05	0.046	8.5E-06	1 2 4
		Benzo(a)pyrene equivalents	0.78	1.8	2.8E-05	0.28	6.5E-06	1 2 3 4
	Inhalation	**Volatile Organics**						
		0	1.5	3.4	ND	0.52	ND	1 3
		Semivolatile Organics	0.0092	0.021	1.4E-06	0.0033	3.3E-07	2
		Benzo(a)pyrene equivalents	0.78	1.8	1.5E-05	0.28	3.6E-06	1 2 3 4
Groundwater Pathway Sum			5	11	1E-04	2	3E-05	
Sum of All Pathways			5	12	1E-04	2	3E-05	

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
Identification of COCs
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

Future Site Residents

Surface Soils

Benzo(a)pyrene equivalents and arsenic were identified as soil pathway COCs based on their contribution to cumulative residential ILCR projections.

Future Site Workers

No soil pathway COCs were identified for the site worker scenario.

The extent of the COCs identified in surface soil is briefly discussed below. In this discussion, residential soil RBCs and background reference concentrations are compared to each reported COC concentration. Benzo(a)pyrene equivalents in two surface soil samples exceeded the residential RBC (163SB001 and 163SB008). Arsenic exceeded its RBC (0.43 mg/kg) in all five surface soil samples, but only slightly exceeded its background reference value (3 mg/kg) in one surface soil sample (163SB002) at a concentration of 3.3 mg/kg.

Shallow Groundwater

Hypothetical Site Residents

Arsenic, bis(2-ethylhexyl)phthalate, tetrachloroethene, and trichloroethene were identified as the groundwater COCs for SWMU 163, based on their contribution to residential risk projections. Arsenic, bis(2-ethylhexyl)phthalate, 1,2-dichloroethene, tetrachloroethene, and trichloroethene were identified as groundwater pathway COCs based on their contribution to residential HI projections.

Hypothetical Site Workers

Arsenic, bis(2-ethylhexyl)phthalate, tetrachloroethene, and trichloroethene were identified as the groundwater COCs for SWMU 163 based on their contribution to site worker risk projections.

Dichloroethene (1,2-) and trichloroethene were identified as groundwater pathway COCs based on their contribution to residential HI projections.

The extent of the COCs identified in shallow groundwater is briefly discussed below.

Arsenic was detected in the first-quarter shallow groundwater sample collected at SWMU 163 at a concentration (1.8 μg/L) exceeding its tap-water RBC (0.045 μg/L). Arsenic was not detected in groundwater samples collected from Zone K grid-based monitoring wells. As a result, an arsenic background reference value was not established. Bis(2-ethylhexyl)phthalate was detected in one of six groundwater samples at a concentration (41 μg/L) exceeding its tap-water RBC (4.8 μg/L). 1,2-dichloroethene was detected in both groundwater samples at concentrations exceeding its tap-water RBC (5.5 μg/L). Tetrachloroethene was detected in two of six groundwater SWMU 163 samples at concentrations exceeding its tap-water RBC of 1.1 μg/L. Trichloroethene was detected in one of six shallow groundwater samples. At a concentration of 170 μg/L, it exceeded its tap-water RBC (1.6 μg/L).

10.3.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. If this area were to be used as a residential site, the surface soil conditions would likely change — the soils could be covered with landscaping soil and/or a house. Consequently, exposure to surface soil conditions as represented by samples collected during the investigation would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

Shallow groundwater is not currently used at SWMU 163 for potable or industrial purposes. A base-wide system provides drinking and process water to buildings throughout Zone K. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios. Therefore, the scenario established to project risk/hazard associated with shallow groundwater exposure is highly conservative, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The maximum detected soil constituent concentrations were used as the exposure point concentrations for this site. Use of maximum detected concentrations represent such conservative assumptions when applied as the EPC, that it is unlikely that the maximum detected concentration would be exceeded by the true mean concentration.

Frequency of Detection and Spatial Distribution

Surface Soil

Benzo(a)pyrene equivalent compounds were detected in six of 10 surface soil samples. Arsenic was detected in all five surface soil samples; however, its maximum concentration only slightly exceeded its background reference concentration.

Shallow Groundwater

Arsenic was detected in the first-quarter shallow groundwater sample collected at SWMU 163 at a concentration (1.8 μg/L) exceeding its tap-water RBC (0.045 μg/L). Arsenic was not detected in groundwater samples collected from Zone K grid-based monitoring wells; as a result, a background reference value was not established for arsenic. Bis(2-ethylhexyl)phthalate was detected in one of six groundwater samples collected a concentration (41 μg/L) exceeding its tap-water RBC (4.8 μg/L). 1,2-dichloroethene was detected 2 of 2 groundwater samples collected at concentrations exceeding its tap-water RBC (5.5 μg/L). Tetrachloroethene was detected in 2 of 6 groundwater samples collected at SWMU 163 at concentrations exceeding its tap-water RBC of 1.1 μg/L. Trichloroethene was detected in 1 of 6 shallow groundwater samples collected at a concentration (170 μg/L) exceeding it tap-water RBC (1.6 μg/L).

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

A conservative screening process was used to identify COPCs for SWMU 163. The potential for eliminating CPSSs with the potential for cumulative HI greater than 1 was addressed for noncarcinogens through the use of RBCs that were reduced one order of magnitude. For carcinogens, the RBCs are based on a conservative target risk of 1E-06. Combining conservative RBCs with maximum detected concentrations minimizes the likelihood of a significant contribution to risk/hazard based on eliminated CPSSs. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration within 10% of its RBC. Although the future land use of SWMU 163 is unknown, both worker and residential exposure scenarios were assessed in this HHRA. As previously discussed, it is likely that these scenarios would lead to overestimates of risk and/or hazard.

Groundwater

The same conservative screening process used for soil is also used for groundwater. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration within 10% of its RBC.

Groundwater is not currently used as a potable water source at SWMU 163, nor is it used for any purpose at CNC or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that, if residences were constructed onsite and an unfiltered well were installed, the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

Background-related Risk

Soil

It is not unusual for naturally occurring or background concentrations of some elements to exceed risk-based concentrations. It is the risk assessment's function to identify excess risk and/or hazard, or that which exceeds background levels.

10.3.6.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 163 were assessed for future site workers and future site residents under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. For groundwater the ingestion and inhalation exposure pathway were assessed. Table 10.3.23 summarizes risk summary for each pathway/receptor group evaluated for SWMU 163.

Table 10.3.23
Summary of Risk and Hazard
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.04	0.4	1E-05	0.01	1E-06
	Dermal Contact	0.008	0.03	3E-06	0.006	1E-06
Sum of Soil Pathways		0.05	0.4	2E-05	0.02	3E-06
Groundwater	Ingestion	2.6	6.0	1E-04	0.92	3E-05
	Inhalation	2	5	2E-05	0.8	4E-06
Sum of Groundwater Pathways		5	11	1E-04	2	3E-05
Sum of All Pathways		5	12	1E-04	2	3E-05

Notes:
ILCR Indicates incremental lifetime cancer risk
HI Indicates hazard index

Soil — Residential Scenario

Residential soil pathway COCs identified for SWMU 163 are arsenic and benzo(a)pyrene equivalents. Figure 10.3.4 illustrates point risk estimates for SWMU 163 based on soil exposure pathways under a future residential scenario. Table 10.3.24 summarizes the risk and hazard contribution of each COPC at each sample location. This point risk map is based on the unlikely assumption that a potential future site resident would be chronically exposed to specific points. Exposure to surface soil conditions would more likely be the result of uniform exposure to the entire site's soil conditions (or exposure unit area) rather than specific points. Risk maps supplemented by tables help the reader visualize how chemicals driving risk estimates are spatially distributed across the site.

Arsenic is a primary contributor to risk estimates exceeding 1E-06 at five of the 10 surface soil sample locations. Benzo(a)pyrene equivalents contributed to risk estimates associated with the remaining five surface soil sample locations. Risk estimates ranged from 2E-07 (163SB006) to 9E-06 (163SB001). The mean risk estimate is 4E-06.

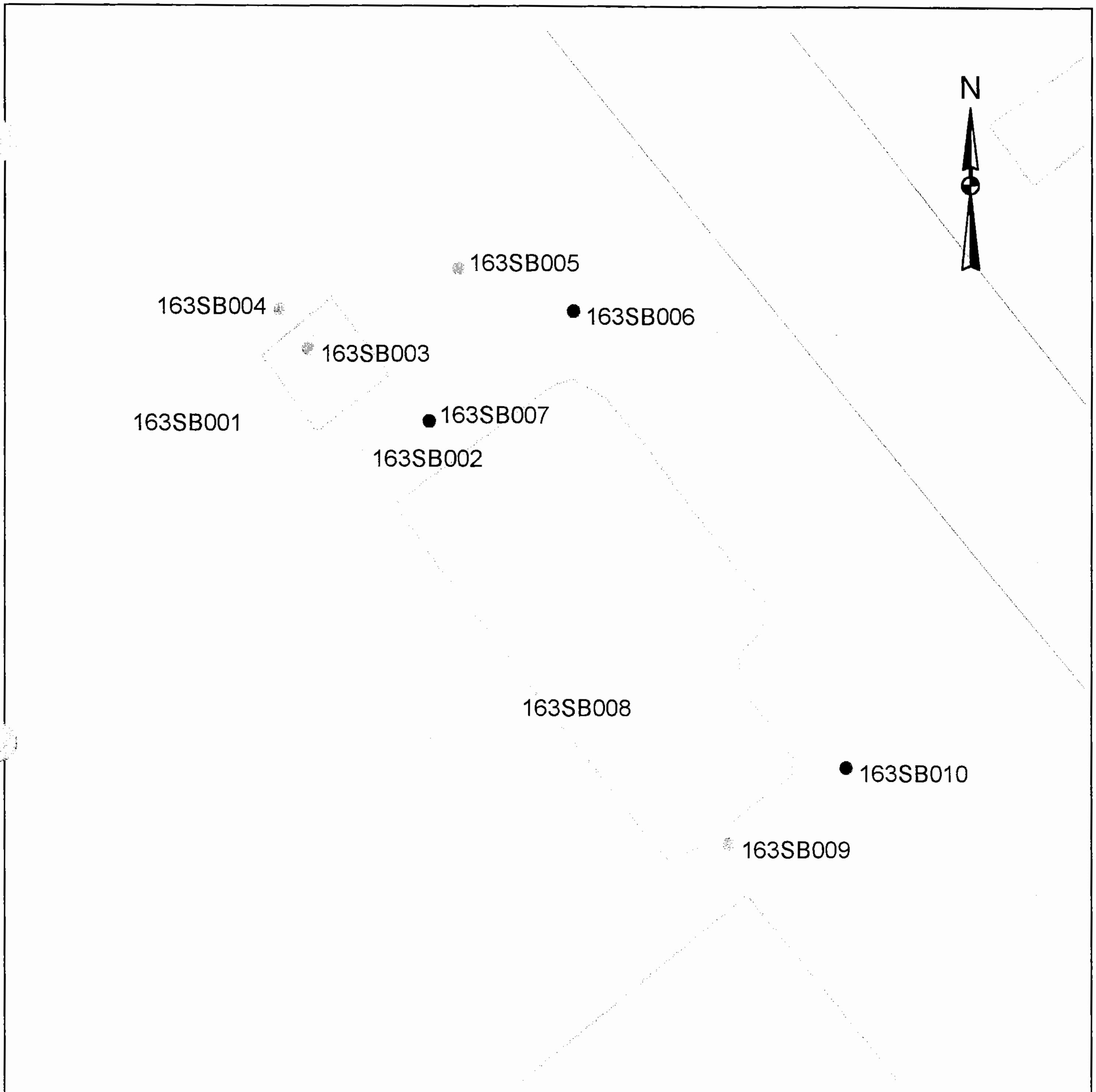
Hazard index estimates ranged from 0.13 (163SB003) to 0.4 (163SB002).

Soil — Site Worker Scenario

No soil pathway COCs were identified for the site worker scenario.

Groundwater — Residential Scenario

Figure 10.3.5 illustrates point risk estimates for SWMU 163 based on groundwater exposure pathways under a future residential scenario. Arsenic, bis(2-ethylhexyl)phthalate, 1,2-dichloroethene, tetrachloroethene, and trichloroethene were identified as groundwater pathway COCs. As shown in Table 10.3.25, these five parameters were contributors to risk estimates,



LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

10 0 10 20 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.3.4
SWMU 163

POINT RISK ESTIMATES FOR
SURFACE SOIL
RESIDENTIAL SCENARIO

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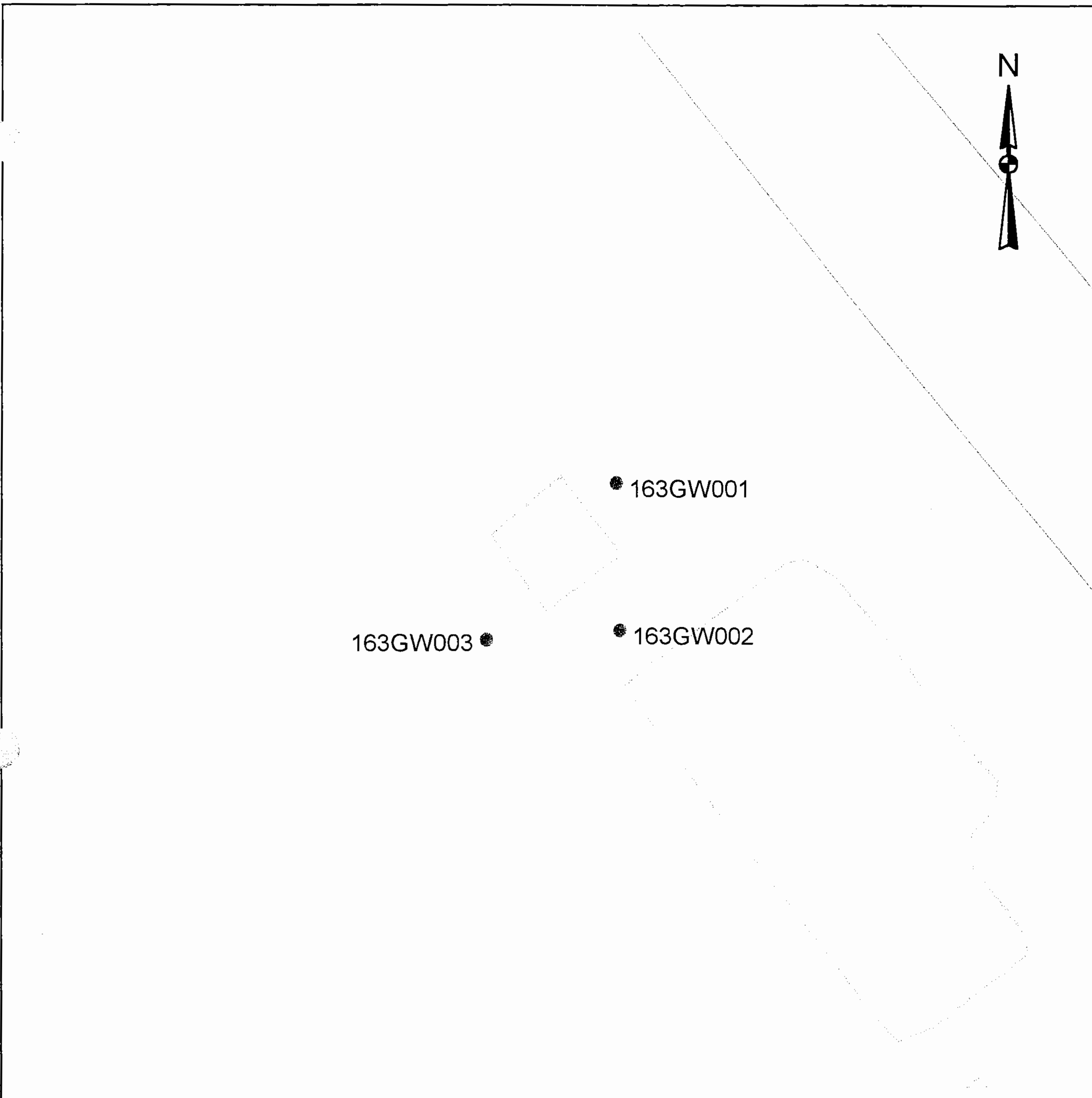
Table10.3.24
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
163	B001	Aluminum (Al)	7790.000	MG/KG	0.1068	44.62	NA	
163	B001	Antimony (Sb)	ND	MG/KG	NA		NA	
163	B001	Arsenic (As)	2.900	MG/KG	0.1326	55.38	7.5748	80.16
163	B001	BEQs	113.200	UG/KG	NA		1.8746	19.84
				Total =	0.2394		9.4494	
163	B002	Aluminum (Al)	7970.000	MG/KG	0.1093	29.28	NA	
163	B002	Antimony (Sb)	3.300	MG/KG	0.1131	30.31	NA	
163	B002	Arsenic (As)	3.300	MG/KG	0.1508	40.41	8.6196	100
163	B002	BEQs	ND	UG/KG	NA		NA	
				Total =	0.3732		8.6196	
163	B003	Aluminum (Al)	5210.000	MG/KG	0.0714	56.57	NA	
163	B003	Antimony (Sb)	ND	MG/KG	NA		NA	
163	B003	Arsenic (As)	1.200	MG/KG	0.0548	43.43	3.1344	100
163	B003	BEQs	ND	UG/KG	NA		NA	
				Total =	0.1263		3.1344	
163	B004	Aluminum (Al)	10000.000	MG/KG	0.1371	61.22	NA	
163	B004	Antimony (Sb)	ND	MG/KG	NA		NA	
163	B004	Arsenic (As)	1.900	MG/KG	0.0868	38.78	4.9628	100
163	B004	BEQs	ND	UG/KG	NA		NA	
				Total =	0.2240		4.9628	
163	B005	Aluminum (Al)	8450.000	MG/KG	0.1159	63.61	NA	
163	B005	Antimony (Sb)	ND	MG/KG	NA		NA	
163	B005	Arsenic (As)	1.450	MG/KG	0.0663	36.39	3.7874	100
163	B005	BEQs	ND	UG/KG	NA		NA	
				Total =	0.1821		3.7874	
163	B006	BEQs	15.000	UG/KG	NA		0.2484	100
				Total =	NA		0.2484	
163	B007	BEQs	21.752	UG/KG	NA		0.3602	100
				Total =	NA		0.3602	
163	B008	BEQs	389.580	UG/KG	NA		6.4516	100
				Total =	NA		6.4516	
163	B009	BEQs	63.725	UG/KG	NA		1.0553	100
				Total =	NA		1.0553	
163	B010	BEQs	21.243	UG/KG	NA		0.3518	100
				Total =	NA		0.3518	

Table10.3.25
Point Estimates of Risk and Hazard - Groundwater Pathways
Residential Scenario
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Round	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
163	W001	01	Arsenic (As)	1.8000	UG/L	0.3836	100	40.1566	100
163	W001	01	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	W001	01	Tetrachloroethene	ND	UG/L	NA		NA	
163	W001	01	Trichloroethene	ND	UG/L	NA		NA	
					Total =	0.3836		40.1566	
163	W001	02	Arsenic (As)	ND	UG/L	NA		NA	
163	W001	02	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	W001	02	Tetrachloroethene	ND	UG/L	NA		NA	
163	W001	02	Trichloroethene	ND	UG/L	NA		NA	
					Total =	NA		NA	
163	W001	03	Arsenic (As)	ND	UG/L	NA		NA	
163	W001	03	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	W001	03	Tetrachloroethene	ND	UG/L	NA		NA	
163	W001	03	Trichloroethene	ND	UG/L	NA		NA	
					Total =	NA		NA	
163	W001	04	Arsenic (As)	ND	UG/L	NA		NA	
163	W001	04	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	W001	04	Tetrachloroethene	ND	UG/L	NA		NA	
163	W001	04	Trichloroethene	ND	UG/L	NA		NA	
					Total =	NA		NA	
163	WC02	01	Arsenic (As)	ND	UG/L	NA		NA	
163	WC02	01	bis(2-Ethylhexyl)phthalate (BEHP)	41.0000	UG/L	0.1311	70.8253	8.5370	84.16
163	WC02	01	1,2-Dichloroethene	2.0000	UG/L	0.0284	15.3551	NA	
163	WC02	01	Tetrachloroethene	2.0000	UG/L	0.0256	13.8196	1.6072	15.84
163	WC02	01	Trichloroethene	ND	UG/L	NA		NA	
					Total =	0.1850		10.1441	
163	WC03	01	Arsenic (As)	ND	UG/L	NA		NA	
163	WC03	01	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	WC03	01	1,2-Dichloroethene	480.0000	UG/L	6.8189	61.7522	NA	
163	WC03	01	Tetrachloroethene	47.0000	UG/L	0.6009	5.44191	37.7681	46.77
163	WC03	01	Trichloroethene	170.0000	UG/L	3.6225	32.8059	42.9824	53.23
					Total =	11.0423		80.7505	



LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

10 0 10 20 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.3.5
SWMU 163

POINT RISK ESTIMATES FOR
GROUNDWATER
RESIDENTIAL SCENARIO

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which ranged from 1E-05 (163GWC0201) to 8E-05 (163GWC0301), with a mean risk estimate of 2E-05.

Hazard index estimates ranged from 0.19 (163GWC0201) to 11.0 (163GWC0301).

Groundwater — Site Worker Scenario

Figure 10.3.6 illustrates point risk estimates for SWMU 163 based on groundwater exposure pathways under a future industrial scenario. Arsenic, bis(2-ethylhexyl)phthalate, 1,2-dichloroethene, tetrachloroethene, and trichloroethene were identified as groundwater pathway COCs. As shown on Table 10.3.26, these same four parameters were contributors to risk estimates ranging from 5E-06 (163GWC0201) to 3E-05 (163GWC0301).

Hazard index estimates ranged from 0.05 (163GWC0201) to 2.5 (163GWC0301).

10.3.6.8 Remedial Goal Options

Soil

RGOs for carcinogens were based on the lifetime-weighted average site resident as presented in Table 10.3.27 for surface soils. Hazard-based RGOs were based on the hypothetical child resident, as noted in the table.

Groundwater

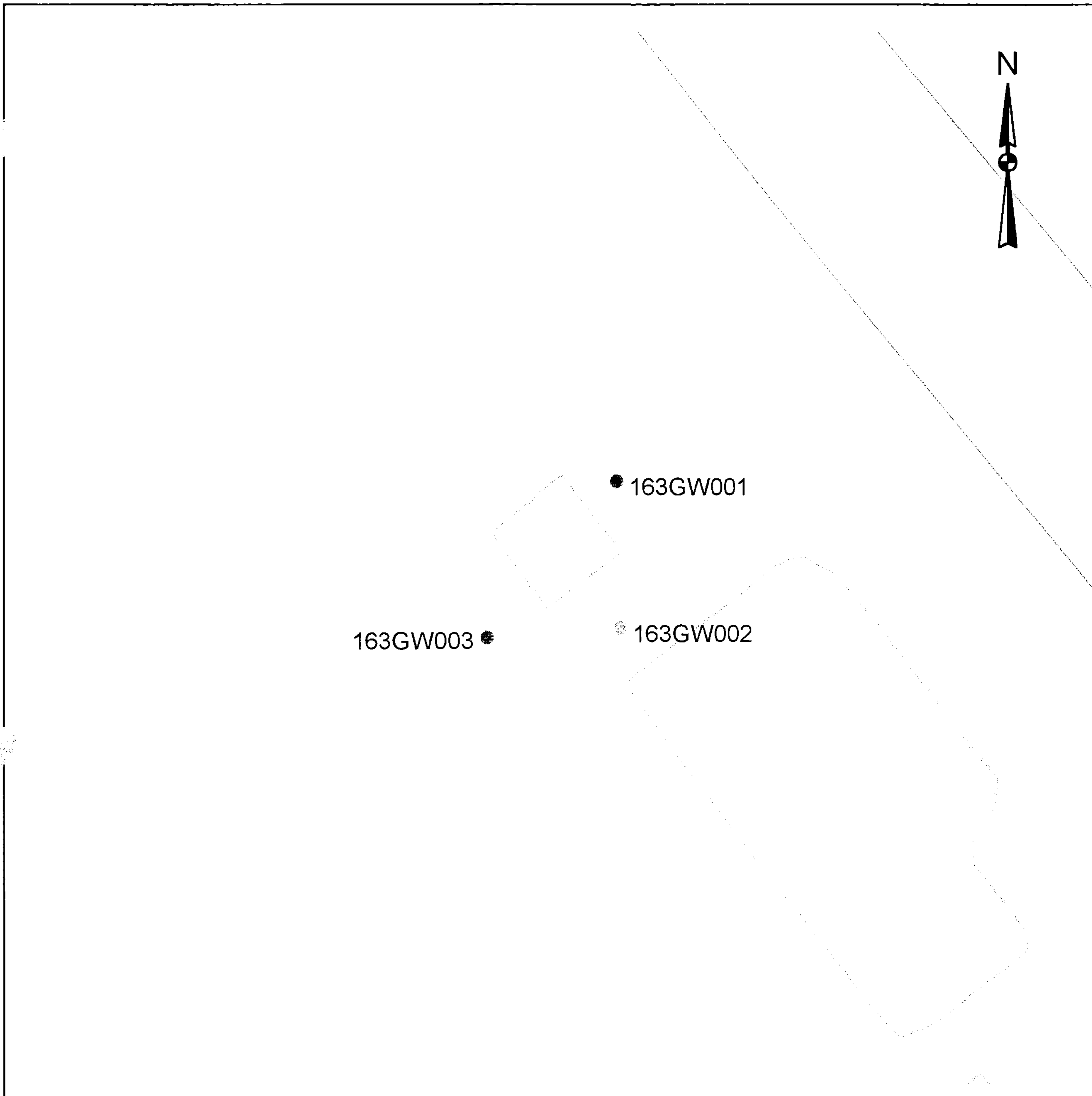
Groundwater RGOs based on the site resident scenario are shown in Table 10.3.28.

10.3.7 Corrective Measures Considerations

SWMU 163's upper and lower soil intervals and shallow groundwater were investigated. Ten soil samples each were collected from the upper and lower-intervals. Three groundwater monitoring well and one Geoprobe location were sampled at the site. Based on the analytical results and the

Table10.3.26
Point Estimates of Risk and Hazard - Groundwater Pathways
Industrial Scenario
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Round	Parameter	Concentratio	Units	Hazard Index	%HI	Risk (E-06)	%Risk
163	W001	01	Arsenic (As)	1.8000	UG/L	0.1174	100	18.8706	100
163	W001	01	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	W001	01	Tetrachloroethene	ND	UG/L	NA		NA	
163	W001	01	Trichloroethene	ND	UG/L	NA		NA	
					Total =	0.1174		18.8706	
163	W001	02	Arsenic (As)	ND	UG/L	NA		NA	
163	W001	02	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	W001	02	Tetrachloroethene	ND	UG/L	NA		NA	
163	W001	02	Trichloroethene	ND	UG/L	NA		NA	
					Total =	NA		NA	
163	W001	03	Arsenic (As)	ND	UG/L	NA		NA	
163	W001	03	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	W001	03	Tetrachloroethene	ND	UG/L	NA		NA	
163	W001	03	Trichloroethene	ND	UG/L	NA		NA	
					Total =	NA		NA	
163	W001	04	Arsenic (As)	ND	UG/L	NA		NA	
163	W001	04	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	W001	04	Tetrachloroethene	ND	UG/L	NA		NA	
163	W001	04	Trichloroethene	ND	UG/L	NA		NA	
					Total =	NA		NA	
163	WC02	01	Arsenic (As)	ND	UG/L	NA		NA	
163	WC02	01	bis(2-Ethylhexyl)phthalate (BEHP)	41.0000	UG/L	0.0401	76.3975	4.0117	84.41
163	WC02	01	1,2-Dichloroethene	2.0000	UG/L	0.0065	12.4224	NA	
163	WC02	01	Tetrachloroethene	2.0000	UG/L	0.0059	11.1801	0.7411	15.59
163	WC02	01	Trichloroethene	ND	UG/L	NA		NA	
					Total =	0.0525		4.7528	
163	WC03	01	Arsenic (As)	ND	UG/L	NA		NA	
163	WC03	01	bis(2-Ethylhexyl)phthalate (BEHP)	ND	UG/L	NA		NA	
163	WC03	01	1,2-Dichloroethene	480.0000	UG/L	1.5656	61.7522	NA	
163	WC03	01	Tetrachloroethene	47.0000	UG/L	0.1380	5.44191	17.4148	51.15
163	WC03	01	Trichloroethene	170.0000	UG/L	0.8317	32.8059	16.6341	48.85
					Total =	2.5352		34.0488	



LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

10 0 10 20 Feet

ZONE K - RCRA
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FIGURE 10.3.6
SWMU 163

POINT RISK ESTIMATES FOR
GROUNDWATER
INDUSTRIAL SCENARIO

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Table 10.3.27
Remedial Goal Options for Soil
SWMU 163
Charleston Naval Complex, Zone K
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Inorganics										
Arsenic (As)	1.5	0.0003	3.3	66	22	2.2	0.38	3.8	38	3
Semivolatile Organics										
Benzo(a)pyrene equivalents	7.3	NA	0.4	ND	ND	ND	0.06	0.6	6	ND

NOTES:
- EPC Exposure point concentration
- NA Not applicable
- ND Not determined
- \- Remedial goal options were based on the residential or site worker lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens

Table 10.3.28
Remedial Goal Options - Shallow Groundwater
SWMU 163
Charleston Naval Complex - Zone K
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Oral SF $(mg/kg\text{-}day)^{-1}$	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options **0.1** mg/l	**1.0** mg/l	**3** mg/l	Risk-Based Remedial Goal Options **1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	MCL mg/l	Background Concentration mg/l
Arsenic	1.5	0.0003	0.0018	0.00047	0.0047	0.014	0.000044	0.00044	0.0044	0.05	ND
bis(2-Ethylhexyl)phthalate	0.014	0.02	0.041	0.031	0.31	0.94	0.0047	0.047	0.47	NA	ND
1,2-Dichloroethene	NA	0.009	0.48	0.0070	0.070	0.21	ND	ND	ND	NA	ND
Tetrachloroethene	0.052	0.01	0.047	0.015	0.15	0.44	0.0012	0.012	0.12	0.005	ND
Trichloroethene	0.011	0.006	0.17	0.0047	0.047	0.14	0.0039	0.039	0.39	0.005	ND

Site Worker-Based Remedial Goal Options

Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options **0.1** mg/l	**1.0** mg/l	**3** mg/l	Risk-Based Remedial Goal Options **1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	MCL mg/l	Background Concentration mg/l
Arsenic	1.5	0.0003	0.0018	0.0031	0.031	0.092	0.00019	0.0019	0.019	0.05	ND
bis(2-Ethylhexyl)phthalate	0.014	0.02	0.041	0.20	2.0	6.1	0.020	0.20	2.0	NA	ND
1,2-Dichloroethene	NA	0.009	0.48	0.05	0.46	1.4	ND	ND	ND	NA	ND
Tetrachloroethene	0.052	0.01	0.047	0.095	0.95	2.9	0.0053	0.053	0.53	0.005	ND
Trichloroethene	0.011	0.006	0.17	0.031	0.31	0.92	0.017	0.17	1.7	0.005	ND

NOTES:
EPC exposure point concentration
NA not applicable
ND not determined
- Residential-based remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcino

human health risk assessment, COCs requiring further evaluation through the CMS process were identified for the upper soil interval and groundwater.

Benzo(a)pyrene equivalents and arsenic were identified as COCs in the upper soil interval. BEQs exceeded the residential RBC in one of five surface soil samples collected (163SB001). Arsenic exceeded its RBC (0.43 mg/kg) in all five surface soil samples. The soil pathway cumulative residential exposure risk is 2E-05 and the cumulative HI is 0.4 (resident child). Both fall between USEPA's acceptable range of 1E-06 and 1E-04 for risk and 3 and 0.1 for HI.

Residential risk-based remedial goals for surface soil set for BEQs, arsenic, and beryllium were 0.06, 0.38, and 0.13 mg/kg, respectively, based on a target risk of 1E-06. Potential corrective measures and respective COCs are presented in Table 10.3.29.

The groundwater pathway cumulative residential exposure risk is 1E-04 and the cumulative HI is 11 (resident child). Residential risk based remedial goals for shallow groundwater were 0.000044 mg/L for arsenic, 0.0047 for bis(2-ethylhexyl)phthalate, 0.0012 mg/L for tetrachloroethene, and 0.0039 mg/L for TCE.

Arsenic, bis(2-Ethylhexyl)phthalate, trichloroethene, tetrachloroethene, and 1,2-dichloroethene were identified as COCs in groundwater at SWMU 163. Potential corrective measures, in addition to no further action for shallow groundwater, and respective COCs are presented in Table 10.3.29.

Table 10.3.29
Potential Corrective Measures for SWMU 163

Medium	Compounds	Potential Corrective Measures
Soil	Arsenic, and benzo(a)pyrene equivalents	a) No Action b) Intrinsic remediation and monitoring c) Containment by capping d) Excavation and landfill, if RCRA-nonhazardous waste e) Insitu, chemical and physical treatment f) Exsitu, chemical and physical treatment
Shallow Groundwater	Arsenic, bis)2-Ethylhexyl)phthalate, trichloroethene, tetrachloroethene, 1,2 dichloroethene	a) No Action b) Intrinsic remediation and monitoring c) Exsitu, chemical and physical treatment

10.4 SWMU 164, Blasting Operation, Naval Annex

SWMU 164 consists of an abrasive sandblasting booth formerly located in Building 2556 at Naval Annex. Building 2556 was constructed in 1983 and used to refurbish and store mines. Various types of equipment were also sandblasted to remove paint. The east side of the building housed the sandblasting booth, a paint booth, and a tool shed, which was once used as a drying booth. (Figure 10.4.1). The building's west side was used for mine storage. Mine refurbishing continued at Building 2556 until 1993. When the concrete floor in the building was inspected in March 9, 1999, it was in good condition and no cracks were observed. It has been reported that the former blasting booth was not constructed in a manner that made it possible to prevent dust emissions. Because the booth was near to the exterior doors, soil near the doors may have been impacted.

A new blasting booth, installed in approximately 1986 on the site of the former blasting booth, consisted of a metal structure on the concrete floor. The booth was installed with a metal grate in the floor to recover abrasive blast media for reuse using a negative pressure system. During operation, exhaust air from the booth, which contained airborne blast media, entered a cyclone separator where particulate matter was removed. However, fugitive airborne particulate, including lead and cadmium particulate, may have been emitted from this system. Dust was noted outside the booth. Because an exterior bay door was approximately 35 feet from the booth, dust from the booth may have migrated from the building and impacted the surrounding soil. A fuel oil aboveground storage tank was also located at the northwest corner of Building 2556. Stains observed on the ground during the 1994 survey could be from leaking pipes leading to Building 2556.

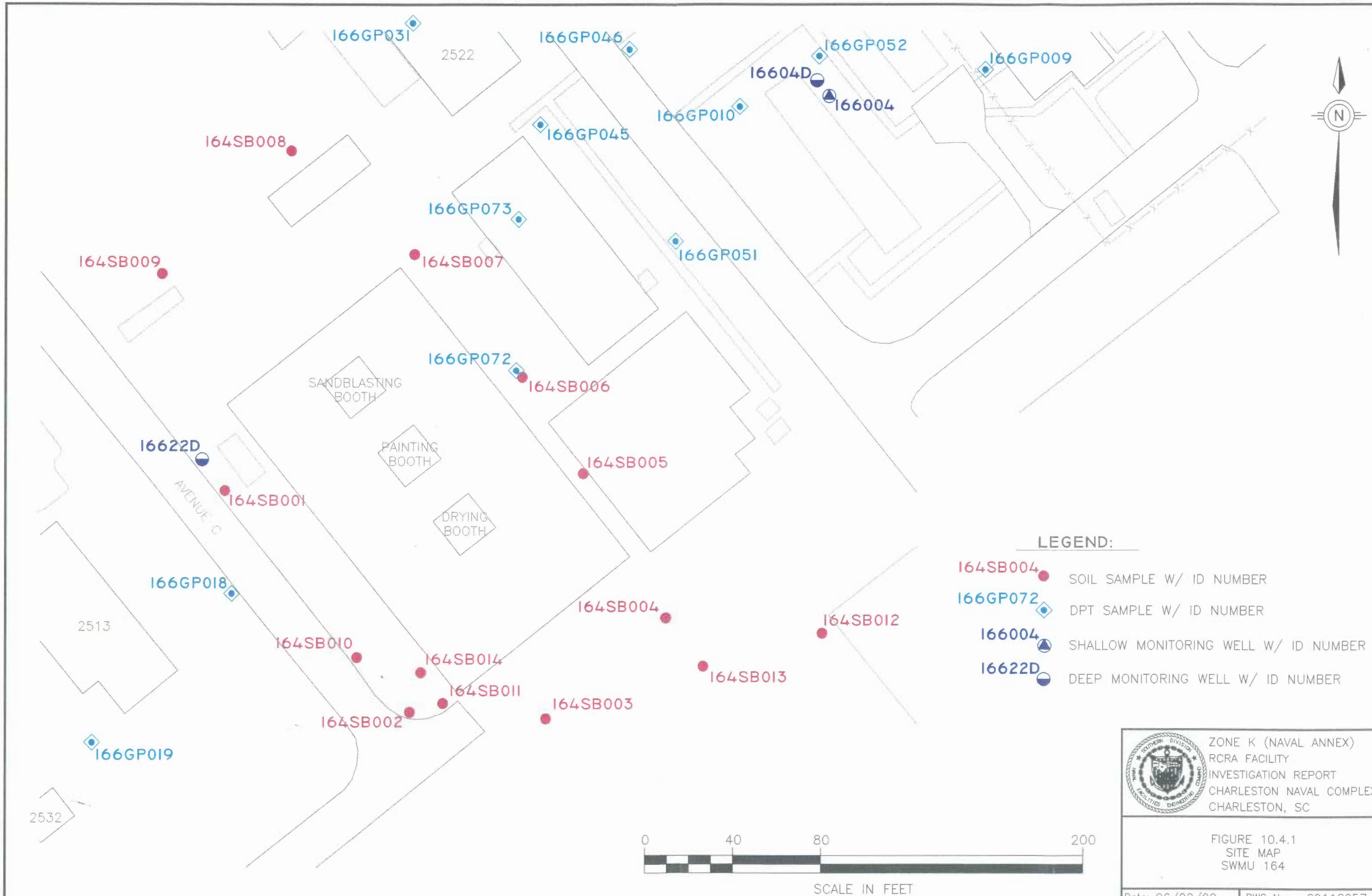
Materials of concern identified in the final RFI work plan for SWMU 164 were metals, PAHs, and petroleum products. Potential receptors are current and future site users involved in excavation.

To fulfill CSI objectives, soil was sampled in accordance with the final RFI work plan and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at SWMU 164. Groundwater was not sampled as a part of the CSI at SWMU 164.

10.4.1 Soil Sampling and Analysis

Soil was sampled in two rounds at SWMU 164 from the locations shown on Figure 10.4.1. The final RFI work plan proposed collection of six soil samples from the upper-interval (0 to 1 foot) and six from the lower-interval (3 to 5 feet) for the SWMU 164 investigation area. However, nine samples each were collected from the upper-interval and lower-interval. During the initial sampling, an additional grassy area was identified in an appropriate location for sampling. The three additional sample were collected from three locations in this area.

The first samples were collected during the Zone K field investigation. During the first-round, SVOCs and arsenic were detected in soil samples. Second-round samples were collected after comparison of first-round analytical results to the USEPA Region III *Risk-Based Concentration Table*, June 1996. This comparison identified arsenic in a sample from 164SB00201 at concentrations exceeding its RBC and noticeably greater than the other samples collected at SWMU 164. The comparison of first-round data to RBCs also identified multiple PAHs in 164SB00401 at concentrations exceeding their RBCs. As part of the Zone K second-round RFI sampling, five additional soil borings were sampled at SWMU 164. Three of the additional soil borings were associated with the arsenic detection at 164SB002. The other two soil borings were associated with the SVOC detections at 164SB004. All soil sampling results are compared to the October 1998 USEPA Region III *Risk-Based Concentration Table* in the following nature and extent discussion.



ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.4.1
SITE MAP
SWMU 164

Date: 06/02/99 | DWG Name: 2911C057

00149T082

First-round samples were submitted for analysis at DQO Level III for SVOCs, metals, and TPH. One duplicate was collected from boring 164SB01's upper-interval and submitted for Appendix IX analyses at DQO Level IV. Second-round samples were submitted for SVOCs and metals at DQO Level III (samples from 164SB010, 11, and 14 were only analyzed for arsenic). Table 10.4.1 summarizes first- and second-round sampling for SWMU 164.

Table 10.4.1
SWMU 164
First- and Second-Round Soil Sampling Summary

Sampling Round	Sample Date	Samples Collected	Sample Analyse	Deviations
1	11/25-26/96	upper - 9 (6) lower - 9 (6) duplicate - 1	SVOCs, metals, and TPH. Appendix IX	Three additional samples were collected for site characterization.
2	2/13/97	upper - 5 (0) lower - 5 (0)	SVOCs and metals	Five additional samples were collected for site characterization. Borings SB010, 11, and 14 were sampled for arsenic only.

Notes:

( )	=	Parentheses indicate number of samples proposed in RFI work plan.
Appendix IX	=	VOCs, SVOCs, metals, cyanide, pesticides, PCBs, hex-chrome, dioxins, herbicides, and OP pesticides at DQO Level IV.

10.4.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.4.2. Inorganic analytical results are summarized in Table 10.4.3. Table 10.4.4 summarizes all analytes detected in soil at SWMU 164. Analyte concentrations are listed in bold type if they exceeded their screening concentrations (the applicable residential soil RBC or SSL and, when available, the associated background concentration). Appendix F is a complete analytical data report for all samples collected in Zone K, including SWMU 164.

Table 10.4.2
SWMU 164
Organics Detected in Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Semivolatile Organic Compounds ($\mu g/kg$)						
14 samples collected, 9 upper-interval, 5 lower-interval, and 2 duplicate samples for Appendix IX analysis.						
BEQs	Upper	4/11	8.5 - 1,496	514	87	3
	Lower	0/11	ND	ND	4,000	0
Benzo(a)anthracene	Upper	3/11	210 - 1,700	720	870	1
	Lower	0/11	ND	ND	800	0
Benzo(a)pyrene	Upper	3/11	180 - 970	457	87	3
	Lower	0/11	ND	ND	400	0
Benzo(b)fluoranthene	Upper	4/11	85 - 1,700	629	870	1
	Lower	0/11	ND	ND	2,300	0
Benzo(k)fluoranthene	Upper	3/11	140 - 370	220	8,700	0
	Lower	0/11	ND	ND	25,000	0
Chrysene	Upper	3/11	180 - 1,300	607	87,000	0
	Lower	0/11	ND	ND	80,000	0
Dibenz(a,h)anthracene	Upper	1/11	130	130	87	1
	Lower	0/11	ND	ND	800	0
Indeno(1,2,3-cd)pyrene	Upper	3/11	130 - 510	267	870	0
	Lower	0/11	ND	ND	7,000	0
Acenaphthene	Upper	1/11	130	130	470,000	0
	Lower	0/11	ND	ND	290,000	0
Anthracene	Upper	1/11	420	420	2,300,000	0
	Lower	0/11	ND	ND	6,000,000	0
Benzo(g,h,i)perylene	Upper	3/11	150 - 450	260	NL	0
	Lower	0/11	ND	ND	57,000,000	0
Carbazole	Upper	1/11	180	180	32,000	0
	Lower	0/11	ND	ND	300	0
Fluoranthene	Upper	5/11	95 - 1,800	635	310,000	0
	Lower	0/11	ND	ND	2,100,000	0
Fluorene	Upper	1/11	81	81	310,000	0
	Lower	0/11	ND	ND	280,000	0
Phenanthrene	Upper	3/11	350 - 1,300	677	NL	NA
	Lower	0/11	ND	ND	660,000	0
Pyrene	Upper	4/11	79 - 1,800	737	230,000	0
	Lower	0/11	ND	ND	2,100,000	0

Table 10.4.2
SWMU 164
Organics Detected in Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Pesticides (μg/kg)						
1 upper-interval duplicate sample for Appendix IX analysis						
4,4'-DDE	Upper	1/1	3.69	3.69	1,900	0
	Lower	0/0	NT	NT	27,000	0
4,4'-DDT	Upper	1/1	18.40	18.4	1,900	0
	Lower	0/0	NT	NT	16,000	0
Aroclor-1254	Upper	1/1	123.00	123	320	0
	Lower	0/0	NT	NT	1,000	0
alpha-Chlordane	Upper	1/1	8.74	8.74	1,800	0
	Lower	0/0	NT	NT	5,000	0
gamma-Chlordane	Upper	1/1	49.60	49.6	1,800	0
	Lower	0/0	NT	NT	5,000	0
Heptachlor expoxide	Upper	1/1	5.89	5.89	70	0
	Lower	0/0	NT	NT	330	0
TPH-DRO (mg/kg)						
18 samples collected, 9 upper-interval, 9 lower-interval, 1 upper-interval duplicate for Appendix IX analysis						
Diesel	Upper	7/9	9.87 - 42.4 11.0	21.28	100[a]	0
	Lower	1/9		11.0	100[a]	0
Dioxins (ng/kg)						
1 upper-interval duplicate for Appendix IX analysis						
TCDD TEQ	Upper	1/1	0.51	0.51	4.3	0
	Lower	0/0	NT	NT	1,600	0

Notes:

a	=	Charleston Naval Complex project screening level
NA	=	Not applicable/not available/not analyzed
ND	=	Not detected/not determined
NL	=	Not listed
NT	=	Not taken
μg/kg	=	Micrograms per kilogram
ng/kg	=	Nanograms per kilogram
mg/kg	=	Milligrams per kilogram

Table 10.4.3
SWMU 164
Inorganics Detected in Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC & Background (upper) or SSL & Background (lower)
Inorganics (mg/kg)							
(28 samples collected; 14 upper-interval samples, 14 lower-interval samples, 1 upper-interval duplicate sample for Appendix IX analysis; both samples from three of the locations were analyzed only for arsenic).							
Aluminum	Upper	11/11	4,720 - 8,510	6,724	11,200*	7,800	0
	Lower	11/11	2,020 - 9,560	6,584	10,500	560,000	0
Antimony	Upper	5/11	0.38 - 0.56	0.46	0.45	3.1	0
	Lower	0/11	ND	ND	**	2.7	NA
Arsenic	Upper	14/14	1.1 - 22.5	5.3	3	0.43[a]	6
	Lower	11/14	0.65 - 7.6	1.6	1.98	15.0	0
Barium	Upper	11/11	9.8 - 23.8	14.8	25.6	550	0
	Lower	11/11	2.3 - 19.9	7.2	6.83	820	0
Beryllium	Upper	11/11	0.03 - 0.23	0.11	0.17	16	0
	Lower	6/11	0.03 - 0.23	0.11	0.12	32	0
Cadmium	Upper	9/11	0.19 - 1.2	0.6	0.13	3.9	0
	Lower	2/11	0.06 - 0.15	0.11	**	4.0	0
Calcium	Upper	11/11	189 - 8,070	3,081	NA	NL	NA
	Lower	11/11	53.6 - 4,200	834	NA	NL	NA
Chromium	Upper	11/11	5.7 - 14.8	8.9	8.4	23	0
	Lower	11/11	2 - 11.3	6	8.76	19	0
Cobalt	Upper	11/11	0.28 - 1.2	0.8	0.34	470	0
	Lower	9/11	0.27 - 0.98	0.72	0.62	990	0
Copper	Upper	11/11	0.94 - 19.5	6.8	3.86	310	0
	Lower	8/11	0.19 - 77.7	10.3	0.34	5,600	0
Iron	Upper	11/11	1,990 - 6,860	3,677	7060	2,300	0
	Lower	11/11	578 - 6,030	2,572	5130	NL	2
Lead	Upper	11/11	8.3 - 114	39	39.6	400[b]	0
	Lower	11/11	2.8 - 41.7	7.6	6.43	400[b]	0
Magnesium	Upper	11/11	147 - 559	239	NA	NL	NA
	Lower	11/11	44.3 - 295	152	NA	NL	NA
Manganese	Upper	11/11	4.7 - 22.9	13.7	26.4	160	0
	Lower	11/11	1.9 - 11.8	5.2	5.93	480	0

Table 10.4.3
SWMU 164
Inorganics Detected in Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC & Background (upper) or SSL & Background (lower)
Mercury	Upper	3/11	0.08 - 0.08	0.08	**	2.3	0
	Lower	1/11	0.23	0.23	**	1.0	0
Nickel	Upper	11/11	1.4 - 4.2	2.8	1.7	160	0
	Lower	11/11	0.16 - 5.1	2.6	2.64	65.0	0
Potassium	Upper	9/11	53.1 - 210	115	NA	NL	NA
	Lower	6/11	15.2 - 151	88	NA	NL	NA
Selenium	Upper	2/11	0.49 - 0.67	0.58	0.84	39	0
	Lower	0/11	ND	ND	0.52	2.6	0
Silver	Upper	0/11	ND	ND	0.44	39	0
	Lower	1/11	0.9	0.9	0.42	17	0
Sodium	Upper	11/11	20.7 - 183	58	NA	NL	NA
	Lower	11/11	16.6 - 72	29	NA	NL	NA
Tin	Upper	1/11	12.3	12.3	19.4	4,700	0
	Lower	1/11	13.7	13.7	**	5,500	0
Vanadium	Upper	11/11	7.2 - 12.5	9.7	15.8	55	0
	Lower	11/11	3.3 - 12.5	7.1	12.2	3,000	0
Zinc	Upper	11/11	11 - 240	79	15	2,300	0
	Lower	5/11	6.1 - 47.5	16.2	**	6,200	0

Notes:
a = RBC for arsenic as a carcinogen.
b = RBC was not available for lead. USEPA residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed
** = Number of nondetects prevented determination of reference concentration.

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Semivolatile Organic Compounds (μg/kg)							
BEQs	164SB004	**1496**	87	NA	ND	4,000	NA
	164SB005	**292**			ND		
	164SB008	**260**			ND		
	164SB009	8.5			ND		
Benzo(a)anthracene	164SB004	**1,700**	870	NA	ND	800	NA
	164SB005	210			ND		
	164SB008	250			ND		
Benzo(a)pyrene	164SB004	**970**	87	NA	ND	400	NA
	164SB005	**220**			ND		
	164SB008	**180**			ND		
Benzo(b)fluoranthene	164SB004	**1,700**	870	NA	ND	2,300	NA
	164SB005	360			ND		
	164SB008	370			ND		
	164SB009	85			ND		
Benzo(k)fluoranthene	164SB004	370	8,700	NA	ND	25,000	NA
	164SB005	150			ND		
	164SB008	140			ND		
Chrysene	164SB004	1,300	87,000	NA	ND	80,000	NA
	164SB005	180			ND		
	164SB008	340			ND		
Dibenz(a,h)anthracene	164SB004	**130**	87	NA	ND	800	NA
Indeno(1,2,3-cd)pyrene	164SB004	510	870	NA	ND	7,000	NA
	164SB005	130			ND		
	164SB008	160			ND		
Acenaphthene	164SB004	130	470,000	NA	ND	290,000	NA

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Anthracene	164SB004	420	2,300,000	NA	ND	6,000,000	NA
Benzo(g,h,i)perylene	164SB004	450	NL	NA	ND	57,000,000	NA
	164SB005	150			ND		
	164SB008	180			ND		
Carbazole	164SB004	180	32,000	NA	ND	300	NA
Fluoranthene	164SB002	95	310,000	NA	ND	2,100,000	NA
	164SB004	1,800			ND		
	164SB005	590			ND		
	164SB008	590			ND		
	164SB009	100			ND		
Fluorene	164SB004	81	310,000	NA	ND	280,000	NA
Phenanthrene	164SB004	1,300	NL	NA	ND	660,000	NA
	164SB005	350			ND		
	164SB008	380			ND		
Pyrene	164SB004	1,800	230,000	NA	ND	2,100,000	NA
	164SB005	380			ND		
	164SB008	690			ND		
	164SB009	79			ND		
Pesticides/PCBs ($\mu g/kg$)							
4,4-DDE	164CB001	3.69	1,900	NA	NT	27,000	NA
4,4-DDT	164CB001	18.4	1,900	NA	NT	16,000	NA
alpha-Chlordane	164CB001	8.74	1,800	NA	NT	5,000	NA
Aroclor-1254	164CB001	123	320	NA	NT	1,000	NA
gamma-Chlordane	164CB001	49.6	1,800	NA	NT	5,000	NA
Heptachlor epoxide	164CB001	5.89	70	NA	NT	330	NA

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Dioxin Compounds (ng/kg)							
TCDD TEQ	164SB001	0.51	4.3	NA	NA	1,600	NA
1234678-HpCDD	164SB001	14.1	430	NA	NT	110,000	NA
1234678-HpCDF	164SB001	3.66	430	NA	NT	54,000	NA
123478-HxCDF	164SB001	1.34	43	NA	NT	220,000	NA
123678-HxCDF	164SB001	0.569	43	NA	NT	220,000	NA
234678-HxCDF	164SB001	0.311	43	NA	NT	220,000	NA
OCDD	164SB001	108	4,300	NA	NT	1,100,000	NA
OCDF	164SB001	6.22	4,300	NA	NT	540,000	NA
TPH-DRO (mg/kg)							
Diesel	164SB001	30.4	100[a]	NA	ND	100[a]	NA
	164SB002	42.4			ND		
	164SB003	9.87			ND		
	164SB004	13			ND		
	164SB005	16.9			11		
	164SB006	13.2			ND		
	164SB008	23.2			ND		

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Inorganics (mg/kg)							
Aluminum (Al)	164SB001	7,365	7,800	11,200	8,020	560,000	10,500
	164SB002	7,130			7,770		
	164SB003	5,740			5,510		
	164SB004	5,670			6,980		
	164SB005	8,240			5,330		
	164SB006	6,160			3,200		
	164SB007	5,330			2,020		
	164SB008	4,720			8,700		
	164SB009	6,800			9,560		
	164SB012	8,510			7,940		
	164SB013	8,300			7,390		
Antimonoy (Sb)	164SB002	0.38	3.1	0.45	ND	2.7	NA
	164SB004	0.43			ND		
	164SB006	0.56			ND		
	164SB007	0.47			ND		
	164SB009	0.44			ND		
Arsenic (As)	164SB001	2.05	0.43	3.0	ND	15	1.98
	164SB002	22.5			7.6		
	164SB003	4.1			0.65		
	164SB004	3.5			1.8		
	164SB005	5			0.65		
	164SB006	2.5			ND		
	164SB007	1.8			ND		
	164SB008	2.4			0.8		
	164SB009	1.1			0.78		
	164SB010	16.1			0.81		
	164SB011	7.9			1		
	164SB012	2.3			1.5		
	164SB013	2.4			0.9		
	164SB014	1.1			0.93		

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Barium (Ba)	164SB001	10.9	550	25.6	8.7	820	6.83
	164SB002	15.9			7.3		
	164SB003	14.9			5		
	164SB004	19.9			6.4		
	164SB005	23.8			19.9		
	164SB006	14.7			3.1		
	164SB007	10.2			2.3		
	164SB008	16.8			6		
	164SB009	12.5			5.9		
	164SB012	13.2			7.7		
	164SB013	9.8			7.2		
Beryllium (Be)	164SB001	0.09	16	0.17	ND	32	0.12
	164SB002	0.19			ND		
	164SB003	0.1			ND		
	164SB004	0.15			0.23		
	164SB005	0.09			0.11		
	164SB006	0.05			0.03		
	164SB007	0.08			ND		
	164SB008	0.23			0.07		
	164SB009	0.03			ND		
	164SB012	0.08			0.14		
	164SB013	0.08			0.07		
Cadmium (Cd)	164SB001	0.865	3.9	0.13	0.06	4	NA
	164SB002	0.34			ND		
	164SB003	0.45			ND		
	164SB004	0.63			ND		
	164SB005	0.99			0.15		
	164SB006	1.2			ND		
	164SB007	0.64			ND		
	164SB009	0.19			ND		
	164SB013	0.28			ND		

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Calcium (Ca)	164SB001	1,270	NL	NA	279	NA	NA
	164SB002	8,070			161		
	164SB003	2,670			131		
	164SB004	5,760			433		
	164SB005	2,600			4,200		
	164SB006	1,910			372		
	164SB007	3,560			222		
	164SB008	1,190			2,290		
	164SB009	5,660			714		
	164SB012	189			53.6		
	164SB013	1,010			318		
Chromium (Cr)	164SB001	14.8	23	8.4	11.3	19	8.76
	164SB002	9			6.5		
	164SB003	7.8			5.3		
	164SB004	8.9			4.9		
	164SB005	14.1			4.7		
	164SB006	7.6			2.6		
	164SB007	9.1			2		
	164SB008	6.4			7.2		
	164SB009	5.7			6.8		
	164SB012	6.4			6.4		
	164SB013	8.2			5.6		

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Cobalt (Co)	164SB001	0.905	470	0.34	0.8	990	0.62
	164SB002	0.85			0.61		
	164SB003	0.91			0.93		
	164SB004	0.77			0.27		
	164SB005	1.2			0.52		
	164SB006	0.93			ND		
	164SB007	0.5			ND		
	164SB008	1.1			0.76		
	164SB009	0.28			0.66		
	164SB012	0.73			0.98		
	164SB013	0.56			0.91		
Copper (Cu)	164SB001	10.35	310	3.86	0.84	5,600	0.34
	164SB002	5.1			0.38		
	164SB003	7			0.94		
	164SB004	8.8			0.7		
	164SB005	7.5			77.7		
	164SB006	19.5			ND		
	164SB007	5.9			ND		
	164SB008	0.94			ND		
	164SB009	3.1			0.19		
	164SB012	2.4			0.66		
	164SB013	4			1.1		

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Iron (Fe)	164SB001	3,045	2,300	7060	1,870	NA	5130
	164SB002	2,800			1,730		
	164SB003	4,220			2,290		
	164SB004	2,920			1,510		
	164SB005	2,840			1,660		
	164SB006	6,860			578		
	164SB007	2,510			1,440		
	164SB008	5,520			5,560		
	164SB009	2,510			2,800		
	164SB012	1,990			6,030		
	164SB013	5,230			2,820		
Lead (Pb)	164SB001	25.5	400[b]	39.6	5.3	400[b]	6.43
	164SB002	26.2			4.1		
	164SB003	25.2			4.3		
	164SB004	39.9			5.7		
	164SB005	114			41.7		
	164SB006	53.8			2.8		
	164SB007	87.9			3.1		
	164SB008	8.5			4		
	164SB009	25.1			4.2		
	164SB012	14.8			3.7		
	164SB013	8.3			4.2		

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Magnesium (Mg)	164SB001	274.5	NL	NA	180	NA	NA
	164SB002	243			112		
	164SB003	187			157		
	164SB004	223			118		
	164SB005	559			211		
	164SB006	159			58.6		
	164SB007	181			44.3		
	164SB008	283			295		
	164SB009	176			248		
	164SB012	147			132		
	164SB013	192			116		
Manganese (Mn)	164SB001	9.9	160	26.4	5.2	480	5.93
	164SB002	12.2			3.2		
	164SB003	15.1			5.1		
	164SB004	13.9			3.2		
	164SB005	21.7			11.8		
	164SB006	22.9			2.2		
	164SB007	12.1			1.9		
	164SB008	16.9			9.9		
	164SB009	13.9			7		
	164SB012	4.7			3.9		
	164SB013	7.1			3.8		
Mercury (Hg)	164SB001	0.08	2.3	NA	ND	1	NA
	164SB004	0.08			ND		
	164SB005	0.08			0.23		

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Nickel (Ni)	164SB001	2.9	160	1.7	2.8	65	2.64
	164SB002	3.8			3.8		
	164SB003	2.1			2.1		
	164SB004	3.1			0.82		
	164SB005	4.2			5.1		
	164SB006	3.2			0.16		
	164SB007	1.6			0.28		
	164SB008	1.4			2.9		
	164SB009	2.6			3.4		
	164SB012	2.6			3.5		
	164SB013	3			3.4		
Potassium (K)	164SB001	113.5	NL	NA	ND	NA	NA
	164SB003	110			88.2		
	164SB004	99.1			ND		
	164SB005	210			115		
	164SB006	53.1			41.4		
	164SB007	101			15.2		
	164SB008	197			151		
	164SB009	72.4			119		
	164SB013	76.2			ND		
Selenium (Se)	164SB002	0.67	39	0.84	ND	2.6	0.52
	164SB007	0.49			ND		
Silver (Ag)	164SB005	ND	39	0.44	0.9	17	0.42

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Sodium (Na)	164SB001	38.35	NL	NA	38.3	NA	NA
	164SB002	183			24.8		
	164SB003	58.7			17.8		
	164SB004	120			36.8		
	164SB005	45.8			72		
	164SB006	40			18.1		
	164SB007	37.9			22.5		
	164SB008	20.7			19		
	164SB009	42.4			29.8		
	164SB012	22.1			16.6		
	164SB013	26			19.8		
Tin (Sn)	164SB001	ND	4,700	19.4	13.7	5,500	NA
	164SB005	12.3			ND		
Vanadium (V)	164SB001	10.4	55	15.8	7.8	3,000	12.2
	164SB002	11.5			8.4		
	164SB003	8.9			3.3		
	164SB004	9.5			4.5		
	164SB005	11.4			6.2		
	164SB006	8			3.8		
	164SB007	7.2			4.5		
	164SB008	9.7			12.1		
	164SB009	8.3			9.1		
	164SB012	9.4			12.5		
	164SB013	12.5			5.4		

Table 10.4.4
SWMU 164
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Zinc (Zn)	164SB001	54.05	2,300	14.8	9.9	6,200	NA
	164SB002	32.8			9.3		
	164SB003	110			8.2		
	164SB004	90.4			ND		
	164SB005	240			47.5		
	164SB006	176			ND		
	164SB007	63			ND		
	164SB008	11			ND		
	164SB009	24.4			6.1		
	164SB012	34.2			ND		
	164SB013	28.9			ND		

Notes:
a = Charleston Naval Complex project screening level

Bold concentrations exceed the RBCs, SSL, and the zone background.
All background values for Zone K are based on twice the means of the grid sample concentrations.

DAF = Dilution attenuation factor
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NT = Not taken
RBC = Risk-based concentration
SSL = Soil screening level
THQ = Target hazard quotient
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogtam

Volatile Organic Compounds in Soil

The duplicate sample (164CB00101) was the only SWMU 164 sample submitted for VOC analysis. No VOCs were detected in that sample.

Semivolatile Organic Compounds in Soil

Fifteen SVOCs were detected in upper-interval soil samples at SWMU 164; no SVOCs were detected in the lower-interval samples. Of the SVOCs detected, four exceeded their RBCs: (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, and dibenzo(a,h)anthracene). Three samples (164SB9004, 164SB005, and 164SB008) contained all of the SVOC RBC exceedances. The calculated BEQs for these samples were 1,496 ppb for 164SB004, 296 ppb for 164SB005, and 260 ppb for 164SB008, each of which exceeded the RBC for benzo(a)pyrene (87μg/kg). Figure 10.4.2 shows BEQ values calculated for surface soil sample locations.

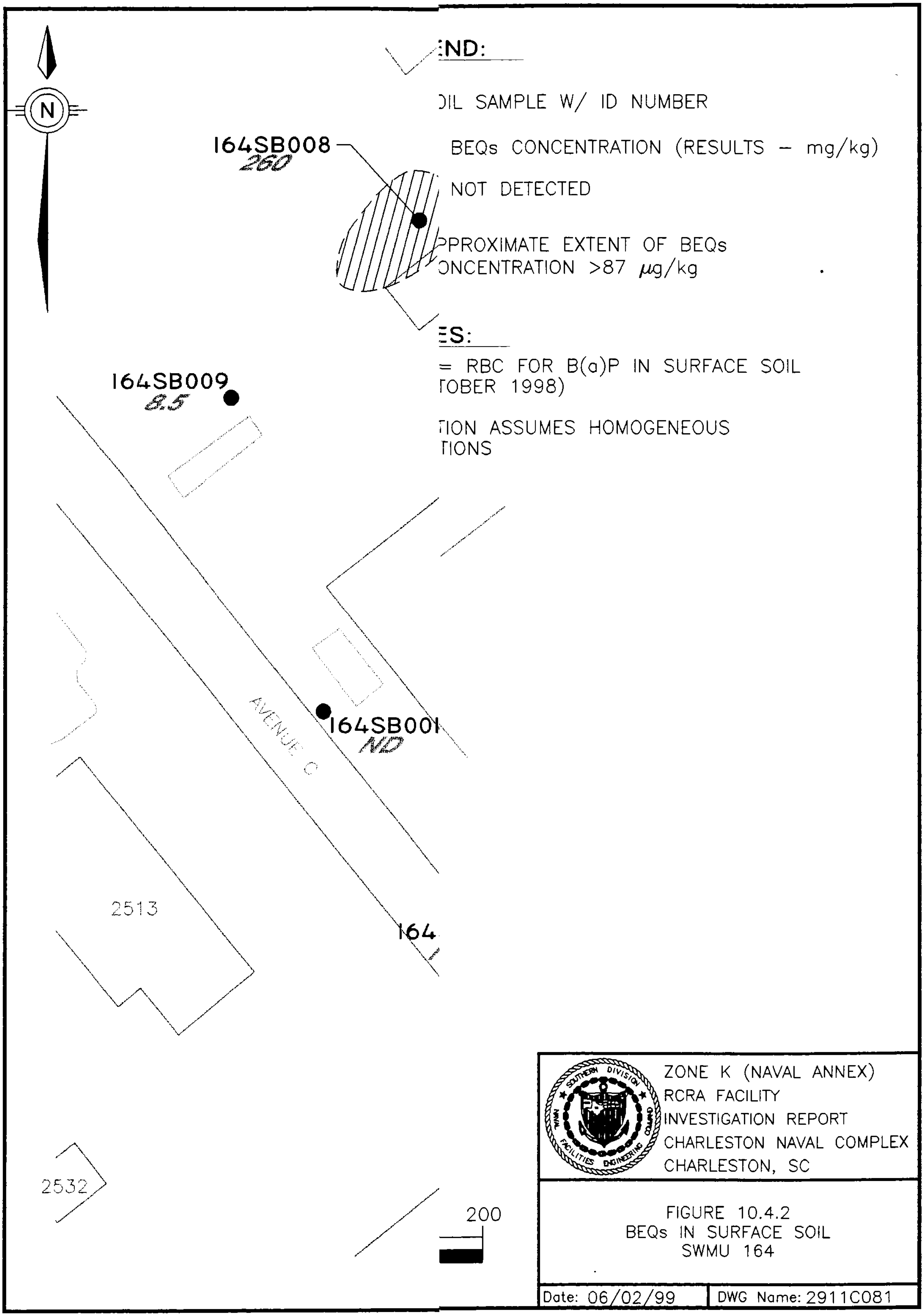
Samples were collected from two additional locations (164SB012 and 164SB013) near 164SB004 and analyzed for SVOCs. Neither sample contained SVOC detections.

Pesticides/PCBs in Soil

The duplicate sample (164CB00101) was the only SWMU 164 sample submitted for pesticide/PCB analysis. One PCB (Aroclor-1254) and five pesticides were detected in this sample. However, none of the pesticide/PCB compounds exceeded their RBCs.

Other Organic Compounds in Soil

Dioxins were detected in the duplicate sample collected at SWMU 164. The calculated TEQ (0.51 ng/kg) was below the 2,3,7,8-TCDD RBC of 4.3 ng/kg.



ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.4.2
BEQs IN SURFACE SOIL
SWMU 164

Date: 06/02/99 | DWG Name: 2911C081

0014...

TPH-DRO was detected at all upper-interval first-round soil sample locations, except 164SB007 and 009. The only second-interval sample in which TPH was detected was at location 164SB005. All of the TPH-DRO concentrations were between 9.8 and 42.4 ppm, which are well below the CNC screening level of 100 ppm.

Inorganics in Soil

Several inorganics were detected in soil samples. Most iron concentrations exceeded the 2,300 mg/kg RBC. However, all iron concentrations were below the applicable surface background concentration. Only one inorganic, arsenic, exceeded both its RBC and background concentrations. All arsenic exceedances were detected in upper-interval samples and were within one order of magnitude of the highest screening concentrations. Figure 10.4.3 shows arsenic concentrations detected in surface soil.

The following inorganics exceeded their respective subsurface background concentrations in lower-level samples: arsenic, barium, beryllium, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, and vanadium. However, none exceeded its SSL, except for iron, which has no reported SSL value.

10.4.3 Fate and Transport Assessment for SWMU 164

Environmental media sampled as part of the SWMU 164 RFI are surface and subsurface soil. Potential constituent migration pathways investigated for SWMU 164 are soil-to-groundwater, and emission of volatiles from surface soil-to-air.

10.4.3.1 SWMU 164 — Soil-to-Groundwater Cross-media Transport

Tables 10.4.5 and 10.4.6 compare maximum detected organic and inorganic concentrations in surface and subsurface soil samples to risk-based soil screening levels considered protective of groundwater. To provide a conservative screen, generic soil screening levels are used; leachate entering the aquifer is assumed to be diluted by a ratio of 10:1, with no attenuation of constituents in soil (DAF=10).

One organic compound was detected in SWMU 164 soil at a concentration exceeding its groundwater protection SSL of 800 μg/kg. Benzo(a)anthracene was detected in three of 13 upper-interval soil samples at concentrations of 210 μg/kg, 250 μg/kg, and 1,700 μg/kg. It was not detected in any lower-interval soil samples. The groundwater protection screening level was exceeded at only one location (164SB004).

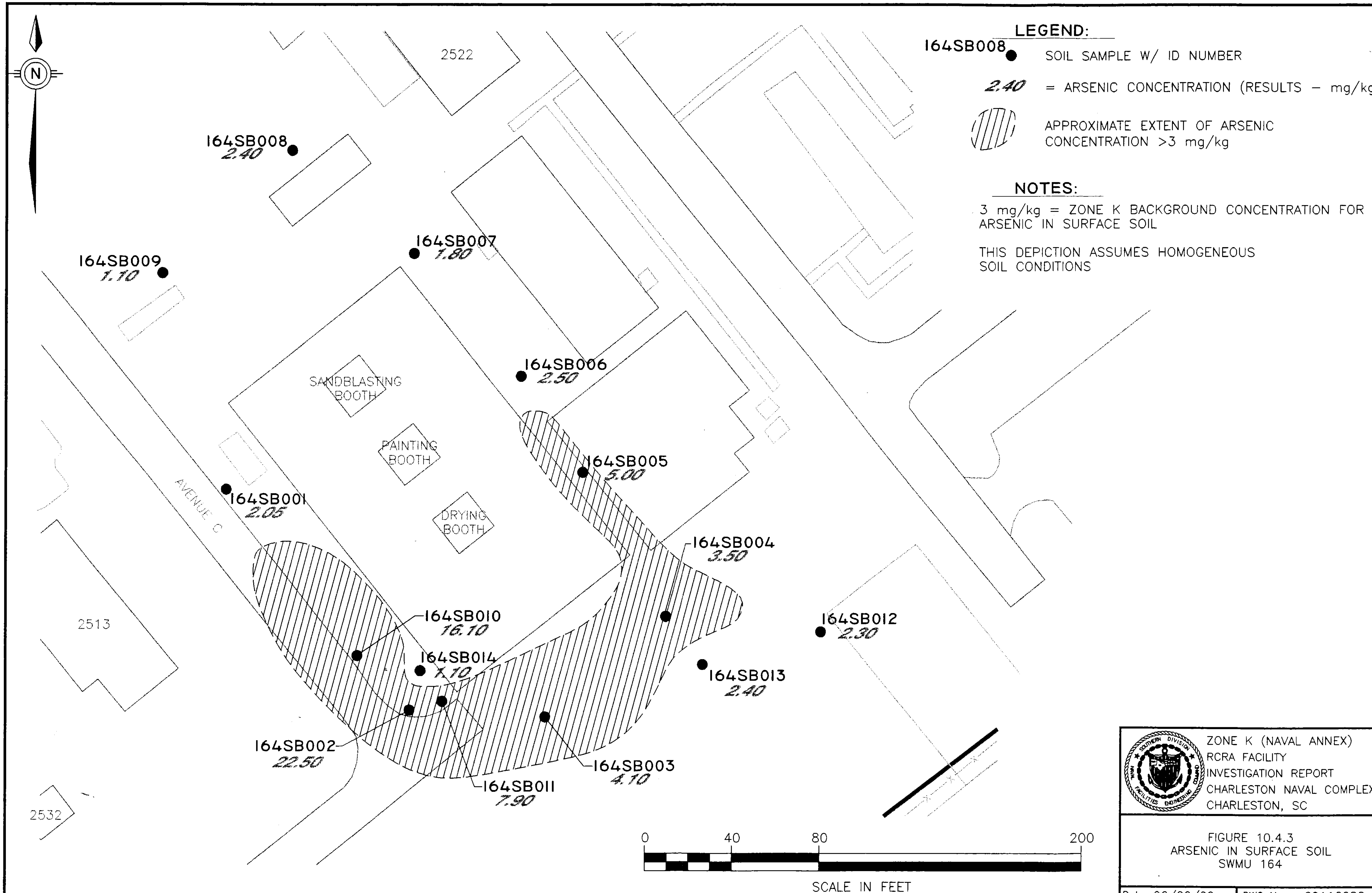
One inorganic was detected in soil at a concentration exceeding its groundwater protection SSL. Arsenic was detected in all 14 upper-interval soil samples (mean of detections = 5.3 mg/kg) and in 11 of 14 lower-interval samples (mean of detections = 1.6 mg/kg). The screening-level exceedances were in the upper-interval samples collected at 164SB002 and 164SB010. Both exceedances (22.5 mg/kg and 16.1 mg/kg) were within the same order of magnitude as the screening concentration (15 mg/kg).

10.4.3.2 SWMU 164 — Soil-to-air Cross-media Transport

No VOCs were detected in surface soil samples collected at SWMU 164. As a result, the soil-to-air migration pathway is not expected to be significant at SWMU 164.

10.4.3.3 SWMU 164 — Fate and Transport Summary

One organic and one inorganic in SWMU 164 soil exceeded their groundwater protection screening levels. All exceedances of groundwater protection standards (one for benzo[a]anthracene, two for arsenic) were in upper-interval samples. In lower-interval samples, mean concentrations of arsenic were much less, while benzo(a)anthracene was not detected at all. Consequently, they are not recommended for further fate and transport assessment.



ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.4.3
ARSENIC IN SURFACE SOIL
SWMU 164

Date: 06/02/99 | DWG Name: 2911C082

Table 10.4.5
Organic Compounds Detected in Surface Soil and Subsurface Soil
Comparison to Soil to Groundwater SSLs, Tap-Water RBCs, and Soil-to-Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: SWMU 164
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurfac Soil	Shallow GW	Screening Concentration * Soil to GW SSL	Tap Water RBC	Soil to Air SSL	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Volatil-ization Potential
Semivolatile Organic Compounds											
Acenaphthene	130	ND	NA	290000	2200	NA	UG/KG	UG/L	NO	NO	NO
Anthracene	420	ND	NA	6000000	11000	NA	UG/KG	UG/L	NO	NO	NO
Benzo(g,h,i)perylene	450	ND	NA	5.7E+07 a	730	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)pyrene equivalents (BEQs) c	1496	ND	NA	NA	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)anthracene c	1700	ND	NA	800	0.092	NA	UG/KG	UG/L	YES	NO	NO
Benzo(a)pyrene c	970	ND	NA	4000	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(b)fluoranthene c	1700	ND	NA	2300 a	0.092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(k)fluoranthene c	370	ND	NA	25000	0.92	NA	UG/KG	UG/L	NO	NO	NO
Chrysene c	1300	ND	NA	80000	9.2	NA	UG/KG	UG/L	NO	NO	NO
Dibenzo(a,h)anthracene c	130	ND	NA	800	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Indeno(1,2,3-cd)pyrene c	510	ND	NA	7000	0.092	NA	UG/KG	UG/L	NO	NO	NO
Carbazole c	180	ND	NA	300	3.3	NA	UG/KG	UG/L	NO	NO	NO
Fluoranthene	1800	ND	NA	2100000	1500	NA	UG/KG	UG/L	NO	NO	NO
Fluorene	81	ND	NA	280000	1500	NA	UG/KG	UG/L	NO	NO	NO
Phenanthrene	1300	ND	NA	660000 a	1100	NA	UG/KG	UG/L	NO	NO	NO
Pyrene	1800	ND	NA	2100000	1100	NA	UG/KG	UG/L	NO	NO	NO
Pesticides/PCB Compounds											
Aroclor-1254 c	123	NA	NA	1000	0.033	1000	UG/KG	UG/L	NO	NO	NO
alpha-Chlordane c	8.74	NA	NA	5000 b	0.19	20000	UG/KG	UG/L	NO	NO	NO
gamma-Chlordane c	49.6	NA	NA	5000 b	0.19	20000	UG/KG	UG/L	NO	NO	NO
4,4'-DDE c	3.69	NA	NA	27000	0.2	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDT c	18.4	NA	NA	16000	0.2	1.0E+09	UG/KG	UG/L	NO	NO	NO
Heptachlor epoxide c	5.89	NA	NA	330	0.0012	5000	UG/KG	UG/L	NO	NO	NO
Dioxin Compounds											
2378-TCDD Equivalents (TEQs) c	0.514	NA	NA	1600 a	0.45	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDD c	14.1	NA	NA	110000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDD c	108	NA	NA	1100000 a	450	NA	NG/KG	PG/L	NO	NO	NO
123478-HxCDF c	1.34	NA	NA	220000 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
123678-HxCDF c	0.569	NA	NA	220000 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
234678-HxCDF c	0.311	NA	NA	220000 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDF c	3.66	NA	NA	54000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDF c	6.22	NA	NA	540000 a	450	NA	NG/KG	PG/L	NO	NO	NO
TPH - Diesel Range Organics											
Diesel	42400	11000	NA	NA	NA	NA	UG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.6
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.4.2

a - Calculated soil-to-groundwater SSL value (See Table 6.4)
b - Based on surrogate compound; see Table 5.6
c - Carcinogen
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration

SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.4.6
Inorganic Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, Soil to Air SSLs, and Background Reference Values
Charleston Naval Complex, Zone K, Naval Annex: SWMU 164
Charleston, South Carolina

	Maximum Concentration			Screening Concentration									
Parameter	Surface Soil	Subsurface Soil	Shallow GW	Soil to GW SSL	Soil Background Reference	Soil to Air SSL	Tap Water RBC	GW Background Reference	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Fugitive Particulate Inhalation Concern
Inorganics													
Aluminum	8510	9560	NA	560000 a	11200	NA	37000	471	MG/KG	UG/L	NO	NO	NO
Antimony	0.56	ND	NA	2.7	0.45	NA	15	NA	MG/KG	UG/L	NO	NO	NO
Arsenic c	22.5	7.6	NA	15	3	750	0.045	NA	MG/KG	UG/L	YES	NO	NO
Barium	23.8	19.9	NA	820	25.6	690000	2600	31.2	MG/KG	UG/L	NO	NO	NO
Beryllium	0.23	0.23	NA	32	0.17	1300	73	NA	MG/KG	UG/L	NO	NO	NO
Cadmium	1.2	0.15	NA	3.8	0.13	1800	18	NA	MG/KG	UG/L	NO	NO	NO
Chromium (total)	14.8	11.3	NA	19 b	8.76	270	110	NA	MG/KG	UG/L	NO	NO	NO
Cobalt	1.2	0.98	NA	990 a	0.62	NA	2200	NA	MG/KG	UG/L	NO	NO	NO
Copper	19.5	77.7	NA	5600 a	3.86	NA	1500	2.8	MG/KG	UG/L	NO	NO	NO
Lead	114	41.7	NA	400 d	39.6	400	15	1.9	MG/KG	UG/L	NO	NO	NO
Manganese	22.9	11.8	NA	480 a	26.4	NA	730	9.3	MG/KG	UG/L	NO	NO	NO
Mercury	0.08	0.23	NA	1	NA	10	11	NA	MG/KG	UG/L	NO	NO	NO
Nickel	4.2	5.1	NA	65	2.64	13000	730	NA	MG/KG	UG/L	NO	NO	NO
Selenium	0.67	ND	NA	2.6	0.84	NA	180	NA	MG/KG	UG/L	NO	NO	NO
Silver	ND	0.9	NA	17	0.44	NA	180	NA	MG/KG	UG/L	NO	NO	NO
Tin	12.3	13.7	NA	5500 a	19.4	NA	22000	102	MG/KG	UG/L	NO	NO	NO
Vanadium	12.5	12.5	NA	3000	15.8	NA	260	0.8	MG/KG	UG/L	NO	NO	NO
Zinc	240	47.5	NA	6200	14.8	NA	11000	NA	MG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.7
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.4.3

Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Assumes hexachrome
c - Carcinogen
d - USEPA de facto residential soil level
GW - Groundwater
NA - Not available/Not applicable

ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

No other fate and transport concerns were identified at SWMU 164.

10.4.4 Human Health Risk Assessment for SWMU 164

10.4.4.1 Site Background and Investigative Approach

SWMU 164 was an abrasive blast booth in Building 2556 at the Naval Annex. Section 10.4.1 summarizes the sampling effort for SWMU 164 soil. Surface soil samples from all 14 boring locations were used to quantitatively assess surface soil exposure pathways. Subsurface soil samples were addressed in the previous section. Fate and Transport Assessment for SWMU 164. No groundwater samples were collected at SWMU 164.

10.4.4.2 COPC Identification

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.4.7, benzo(a)pyrene equivalents and arsenic were identified as COPCs in surface soil. Wilcoxon rank sum test analysis resulted in aluminum being a COPC on the basis of background concentration comparison.

10.4.4.3 Exposure Assessment

SWMU 164 is on the corner of Sixth Street and C Avenue. Building 2556, which houses the abrasive blast booth, is in the middle of the site.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents and/or adolescent site trespassers. Future site resident and future site worker exposure scenarios were addressed quantitatively in this risk assessment. Current exposure to workers is discussed qualitatively in relation to the future workers and future residents. The hypothetical future site worker scenario assumes continuous

Table 10.4.7
Chemicals Present in Site Samples
SWMU 164 - Surface Soil
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Conc.	Range of SQL		Screening Concentration Residential		Units	Number Exceeding	
									RBC	Reference		RBC	Ref
TPH - Diesel Range Organics													
Diesel		7	9	9.87	42.4	21.28	5.34	5.47	100	NA	MG/KG		
Carcinogenic PAHs													
B(a)P Equiv.	*	4	1	8.5	1498	514	808.85	878.18	87	NA	UG/KG	3	
Benzo(a)anthracene	*	3	1	210	1700	720	350	380	870	NA	UG/KG	1	
Benzo(a)pyrene	*	3	1	180	970	457	350	380	87	NA	UG/KG	3	
Benzo(b)fluoranthene	*	4	1	85	1700	629	350	380	870	NA	UG/KG	1	
Benzo(k)fluoranthene		3	1	140	370	220	350	380	8700	NA	UG/KG		
Chrysene		3	1	180	1300	607	350	380	87000	NA	UG/KG		
Dibenz(a,h)anthracene	*	1	1	130	130	130	350	380	87	NA	UG/KG	1	
Indeno(1,2,3-cd)pyrene		3	1	130	510	267	350	380	870	NA	UG/KG		
TCDD Equivalents													
1234678-HpCDD		1	1	14.1	14.1	14.1	NA	NA	NA	NA	NG/KG		
1234678-HpCDF		1	1	3.66	3.66	3.66	NA	NA	NA	NA	NG/KG		
123478-HxCDF		1	1	1.34	1.34	1.34	NA	NA	NA	NA	NG/KG		
123678-HxCDF		1	1	0.569	0.569	0.569	NA	NA	NA	NA	NG/KG		
234678-HxCDF		1	1	0.311	0.311	0.311	NA	NA	NA	NA	NG/KG		
Dioxin Equiv.		1	1	0.5138	0.5138	0.5138	NA	NA	1000[a]	NA	NG/KG		
OCDD		1	1	108	108	108	NA	NA	NA	NA	NG/KG		
OCDF		1	1	6.22	6.22	6.22	NA	NA	NA	NA	NG/KG		
Inorganics													
Aluminum (Al)		11	1	4720	8510	6724	NA	NA	7800	11200	MG/KG	3	
Antimony (Sb)		5	1	0.38	0.56	0.46	0.29	0.4	3.1	0.45	MG/KG		2
Arsenic (As)	*	14	1	1.1	22.5	5.34	NA	NA	0.43	3	MG/KG	14	6
Barium (Ba)		11	1	9.8	23.8	14.78	NA	NA	550	25.6	MG/KG		
Beryllium (Be)		11	1	0.03	0.23	0.11	NA	NA	16	0.17	MG/KG		2
Cadmium (Cd)		9	1	0.19	1.2	0.62	0.04	0.2	3.9	0.13	MG/KG		9
Calcium (Ca)		11	1	189	8070	3081	NA	NA	NA	NA	MG/KG		
Chromium (Cr)		11	1	5.7	14.8	8.91	NA	NA	23	8.4	MG/KG		5
Cobalt (Co)		11	1	0.28	1.2	0.79	NA	NA	470	0.34	MG/KG		10
Copper (Cu)		11	1	0.94	19.5	6.78	NA	NA	310	3.86	MG/KG		8
Iron (Fe)		11	1	1990	6860	3677	NA	NA	2300	7060	MG/KG	10	
Lead (Pb)		11	1	8.3	114	39.02	NA	NA	400	39.6	MG/KG		4
Magnesium (Mg)		11	1	147	559	239	NA	NA	NA	NA	MG/KG		
Manganese (Mn)		11	1	4.7	22.9	13.67	NA	NA	180	26.4	MG/KG		
Mercury (Hg)		3	1	0.08	0.08	0.08	0.05	0.06	2.3	NA	MG/KG		
Nickel (Ni)		11	1	1.4	4.2	2.77	NA	NA	160	1.7	MG/KG		9
Potassium (K)		9	1	53.1	210	115	70.7	80.4	NA	NA	MG/KG		
Selenium (Se)		2	1	0.49	0.67	0.58	0.4	0.56	39	0.84	MG/KG		
Sodium (Na)		11	1	20.7	183	57.72	NA	NA	NA	NA	MG/KG		
Tin (Sn)		1	1	12.3	12.3	12.30	10.2	11	4700	19.4	MG/KG		
Vanadium (V)		11	1	7.2	12.5	9.71	NA	NA	55	15.8	MG/KG		
Zinc (Zn)		11	1	11	240	78.61	NA	NA	2300	14.8	MG/KG		10
Pesticides/PCBs													
Aroclor-1254		1	1	123	123	123	NA	NA	320	NA	UG/KG		
4,4'-DDE		1	1	3.69	3.69	3.69	NA	NA	1900	NA	UG/KG		
4,4'-DDT		1	1	18.4	18.4	18.4	NA	NA	1900	NA	UG/KG		
alpha-Chlordane		1	1	8.74	8.74	8.74	NA	NA	1800	NA	UG/KG		
gamma-Chlordane		1	1	49.6	49.6	49.6	NA	NA	1800	NA	UG/KG		
Heptachlor epoxide		1	1	5.89	5.89	5.89	NA	NA	70	NA	UG/KG		
Semivolatile Organics													
Acenaphthene		1	1	130	130	130	350	380	470000	NA	UG/KG		
Anthracene		1	1	420	420	420	350	380	2300000	NA	UG/KG		
Benzo(g,h,i)perylene		3	1	150	450	260	350	380	160000	NA	UG/KG		
Carbazole		1	1	180	180	180	350	380	32000	NA	UG/KG		
Fluoranthene		5	1	95	1800	635	350	380	160000	NA	UG/KG		
Fluorene		1	1	81	81	81	350	380	310000	NA	UG/KG		
Phenanthrene		3	1	350	1300	677	350	380	310000	NA	UG/KG		
Pyrene		4	1	79	1800	737	350	380	230000	NA	UG/KG		

Notes:
* - Indicates chemical was identified as a COPC
a - Reported soil concentrations of dioxins (as TEQs) were compared to the project screening level.
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/KG - micrograms per kilogram
NG/KG - nanograms per kilogram
MG/KG - milligrams per kilogram
NA - Not applicable or not available

Reported soil concentrations of managanese were compared to the RBC associated with food exposures exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact. Therefore, future worker assessment is considered to conservatively represent current site users. The future site resident scenario was built on the premise that existing fixtures would be removed and replaced with dwellings.

Exposure Pathways

Exposure pathways for the hypothetical future site residents and site workers are dermal contact and incidental ingestion of surface soils. The exposure pathways for current site workers are the same as those for the future site residents with respect to soil. Uniform exposure was assumed for all sample locations. Table 10.4.8 presents the justification for exposure pathways assessed in this HHRA.

Table 10.4.8
Exposure Pathways Summary - SWMU 164
CNC - Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Users (Site Workers)	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or process water at SWMU 164.
	Shallow groundwater, inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or process water at SWMU 164.
	Soil, incidental ingestion	No (Qualified)	Future site use is considered conservatively representative of current site use.

Table 10.4.8
Exposure Pathways Summary - SWMU 164
CNC - Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Soil, dermal contact	No (Qualified)	Future site use is considered conservatively representative of current site use.
Future Land Uses			
Future Site Residents (Child and Adult), Future Site Worker, Trespasser	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Fate and transport did not identify any COPCs for this indirect exposure pathway.
	Shallow groundwater, inhalation of volatilized contaminants during domestic use	No	No COPCs were identified for this indirect exposure pathway.
	Soil, incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, city limits.
	Fruits and vegetables, ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

Exposure point concentrations were set equal to the 95% upper confidence limit (UCL) for arsenic and aluminum. Since the 95% UCL for benzo(a)pyrene equivalents exceeded its maximum concentration, the maximum detected concentration was used as its exposure point concentration. The statistical analysis is summarized in Table 10.4.9.

Quantification of Exposure

CDIs for ingestion and dermal contact with soils are shown in Tables 10.4.10 and 10.4.11, respectively.

10.4.4.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.4.12 presents toxicological information specific to each COPC identified at SWMU 164. This information was used to quantify risk/hazard associated with soil contaminants. Each COPC's toxicology is briefly profiled in the following paragraphs.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.3 μg/kg/day as the RfD for arsenic based on a NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg/day)^{-1}$ slope factor (SF). As listed in IRIS, the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Human milk contains about 3 μg/L arsenic. As listed in IRIS, the critical effect of this

Table 10.4.9
Summary of Statistical Analysis
Surface Soil COPCs; SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

COPC	Natural Log Transformed n	mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)	
Inorganics								
Arsenic (As)	14	1.231	0.902	2.642	9.96	22.5	9.96	UCL
Aluminum (Al)	11	8.796	0.198	1.860	7569	8510	7569	UCL
Semivolatile Organics								
Benzo(a)pyrene equivalents	11	5.730	1.270	3.557	2.88	1.5	1.5	Max

NOTES:
- mean Arithmetic mean of the log-transformed data
- n Number of samples analyzed
- SD Standard deviation for a sample of data
- H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Term
- NA Not applicable
- EPC Exposure point concentration
- UCL 95 percentile upper confidence level mean
- MAX Maximum reported concentration

Table 10.4.10
Chronic Daily Intakes
Incidental Ingestion of Surface Soil
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganics							
Arsenic (As)	1	9.96	1.4E-05	1.3E-04	1.6E-05	4.9E-06	1.7E-06
Aluminum (Al)	1	7569	1.0E-02	9.7E-02	1.2E-02	3.7E-03	1.3E-03
Semivolatile Organics							
Benzo(a)pyrene equivalents	1	1.5	2.0E-06	1.9E-05	2.3E-06	7.3E-07	2.6E-07

NOTES:

LWA Lifetime-weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.4.11
Chronic Daily Intakes
Dermal Contact with Surface Soil
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	FI/FC *	Exposure Point Concentration (mg/kg)	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident lwa C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganics								
Arsenic (As)	1	9.96	0.001	5.6E-07	1.8E-06	3.5E-07	4.0E-07	1.4E-07
Aluminum (Al)	1	7569	0.001	4.3E-04	1.4E-03	2.7E-04	3.0E-04	1.1E-04
Semivolatile Organics								
Benzo(a)pyrene equivalents	1	1.5	0.01	8.4E-07	2.8E-06	5.3E-07	6.0E-07	2.1E-07

NOTES:

CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.
\- The dermal absorption factor was applied to the exposure point concentration to reflect the ability for transdermal migration of inorganic and organic chemicals.

Table 10.4.12
Toxicological Reference Information
for Chemicals of Potential Concern
SWMU 164
Charleston Naval Complex
Charleston, South Carolina

	Non-carcinogenic Toxicity Data									*Carcinogenic Toxicity Data*					
Chemical	**Oral Reference Dose (mg/kg-day)**		**Confidence Level**	**Critical Effect**	**Uncertainty Factor Oral**	**Inhalation Reference Dose (mg/kg-day)**	**Confidence Level**	**Critical Effect**	**Uncertainty Factor Inhalation**	**Oral Slope Factor (kg-day/mg)**		**Inhalation Slope Factor (kg-day/mg)**		**Weight of Evidence**	**Tumor Type**
Aluminum	1	d	NA	NA	NA	NA	NA	NA	NA	NA		NA		NA	NA
Arsenic	0.0003	a	M	hyperpigmentation	3	NA	NA	NA	NA	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	NA		NA	NA	NA	NA	NA	NA	NA	7.3	a	6.1	b	B2	mutagen

Notes:

a = Integrated Risk Information System (IRIS)
b = Withdrawn from IRIS/HEAST
d = EPA-National Center for Environmental Assessment Cincinnati (Provisional).
A = Known human carcinogen
B2 = Possible human carcinogen based on laboratory animal study data.
NA = Not applicable or not available
L = Low confidence
M = Medium confidence

chemical is hyperpigmentation, keratosis, and possible vascular complications. The uncertainty factor was determined to be 3 and the modifying factor was determined to be 1.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. The metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuromuscular system controlling bowel muscles. (The effect could explain why aluminum containing antacids often produce constipation and indicates aluminum could affect the uptake of other chemicals.) Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaasen, et al., 1986; Dreisbach et al., 1987). No data are available on an applicable SF or the USEPA conager group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg/day. The aesthetic-based secondary MCL for drinking water is 50 to 200 μg/L.

Benzo(a)pyrene equivalents include the following list of polynuclear aromatic hydrocarbons (PAHs):

	TEF
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Dibenz(a,h)anthracene	1.0
Benzo(k)fluoranthene	0.01
Benzo(a)pyrene	1.0
Indeno(1,2,3-cd)pyrene	0.1
Chrysene	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. They have no RfDs due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF of 7.3 $(mg/kg/day)^{-1}$. Toxicity Equivalency Factors, also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS, the basis for the benzo(a)pyrene B2 classification is animal studies. Human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

10.4.4.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.4.13 and 10.4.14 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime weighted average) for SWMU 164 surface soils is 4E-5. The dermal pathway ILCR is 1E-5. Benzo(a)pyrene equivalents and arsenic were the primary contributors to ILCR projections for the ingestion and dermal pathways.

Table 10.4.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganics							
Arsenic (As)	0.0003	1.5	0.045	0.42	2.3E-05	0.016	2.6E-06
Aluminum (Al)	1	NA	0.01	0.1	NA	0.0037	NA
Semivolatile Organics							
Benzo(a)pyrene equivalents	NA	7.3	NA	NA	1.7E-05	NA	1.9E-06
SUM Hazard Index/ILCR			0.056	0.52	4E-05	0.020	5E-06

NOTES:

NA	Not available
ND	Not determined due to lack of available information
LWA	Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR	Incremental Lifetime Cancer Risk

Table 10.4.14
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganics								
Arsenic (As)	0.2	0.00006	7.5	0.0093	0.031	2.6E-06	0.0067	1.1E-06
Aluminum (Al)	0.2	0.20	NA	0.0021	0.0070	NA	0.0015	NA
Semivolatile Organics								
Benzo(a)pyrene equivalents	0.5	NA	14.6	NA	NA	7.7E-06	NA	3.1E-06
SUM Hazard Index/ILCR				0.011	0.038	1E-05	0.0082	4E-06

NOTES:
NA Not available
ND Not determined due to lack of available information
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI).

The ingestion HIs projected for the adult and child receptors are 0.056 and 0.52, respectively. The dermal pathway HIs were 0.011 for the adult resident receptor and 0.038 for the child resident receptor.

Hypothetical Site Workers

Site worker ILCRs are 5E-06 and 4E-06 for the ingestion and dermal contact pathways, respectively. Benzo(a)pyrene equivalents and arsenic were the primary contributors to risk estimates for each pathway.

Site worker HIs are 0.02 for the ingestion pathway and 0.0082 for the dermal pathway.

COCs Identified

Identification of chemicals of concern was based on cumulative (all pathway) risk and hazard projected for this site on a medium-specific basis. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). As recommended by SCDHEC, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index above 1.0, if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to more comprehensively evaluate chemicals contributing to carcinogenic risk or noncarcinogenic hazard during remedial goal options development. Table 10.4.15 presents the COCs identified for SWMU 164 surface soil.

Table 10.4.15
Summary of Risk and Hazard-based COCs
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient (HI)	Future Resident Child Hazard Quotient (HI)	Future Resident LWA ILCR	Current Site Worker Hazard Quotient	Current Site Worker ILCR	Identification of COCs	
Surface Soil	Incidental Ingestion	**Inorganics**							
		Arsenic (As)	0.045	0.42	2.3E-05	0.016	2.6E-06	2	4
		Aluminum (Al)	0.010	0.10	ND	0.0037	ND		
		Semivolatile Organics							
		Benzo(a)pyrene equivalents	ND	ND	1.7E-05	ND	1.9E-06	2	4
	Dermal	**Inorganics**							
		Arsenic (As)	0.0093	0.031	2.6E-06	0.0067	1.1E-06	2	4
		Aluminum (Al)	0.0021	0.0070	ND	0.0015	ND		
		Semivolatile Organics							
		Benzo(a)pyrene equivalents	ND	ND	7.7E-06	ND	3.1E-06	2	4
Surface Soil Pathway Sum			0.067	0.56	5E-05	0.028	9E-06		

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk.
HI indicates hazard index.
Identification of COCs
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Chemical is a COC by virtue of projected site worker ILCR.

Surface Soils

Future Site Residents

Benzo(a)pyrene equivalents and arsenic were identified as soil pathway COCs based on their contribution to cumulative residential ILCR projections.

Future Site Workers

Benzo(a)pyrene equivalents and arsenic were identified as soil pathway COCs based on their contribution to cumulative industrial ILCR projections.

The extent of the COCs identified in surface soil is briefly discussed below. To facilitate this discussion, residential soil RBCs and background reference concentrations were compared to each reported COC concentration. Benzo(a)pyrene equivalents exceeded the residential RBC in three of 11 surface soil samples collected at SWMU 164 (164SB004, 164SB005, and 164SB008). Arsenic exceeded its RBC in all 14 surface soil samples, but its background reference value in only six surface soil samples.

10.4.4.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. If this area were to be used as a residential site, the surface soil conditions would likely change — soils could be covered with landscaping soil and/or a house. Consequently, exposure to surface soil conditions, as represented by samples collected, would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site Residents.

Determination of Exposure Point Concentrations

Exposure point concentrations were set equal to the 95% UCL for arsenic and aluminum. Use of the 95% UCL represents such a conservative assumption when applied as an EPC, that it is unlikely that the 95% UCL would be exceeded by the true mean concentration. The maximum concentration of benzo(a)pyrene equivalents was used as an EPC since its 95% UCL exceeded the maximum concentration. Because elevated concentrations of benzo(a)pyrene equivalents were isolated to a small area, the use of the maximum concentration as its EPC likely overestimates risk associated with this group.

Frequency of Detection and Spatial Distribution

Benzo(a)pyrene equivalent compounds exceeded risk-based concentrations in three of 11 surface soil samples, with the highest concentration reported for sample 164SB004 across Sixth Street from Building 2556. The other two benzo(a)pyrene exceedances were approximately five times lower than the highest concentration. Arsenic exceeded its RBC in all 14 surface soil samples, but its background reference concentration in only six surface soil samples. The highest arsenic concentrations were reported at the corner of Sixth Street and C Avenue. Arsenic concentrations reported for the remaining surface soil samples were at least five times lower than its highest concentration. Beryllium exceeded its RBC in three surface soil samples and its background reference concentration in two surface soil samples.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

A conservative screening process was used to identify COPCs for SWMU 164. The potential for eliminating CPSSs with the potential for cumulative HI greater than 1 was addressed for noncarcinogens through the use of RBCs that were reduced one order of magnitude. For carcinogens, the RBCs are based on a conservative target risk of 1E-06. Combining conservative RBCs with maximum detected concentrations minimizes the likelihood of a significant contribution to risk/hazard based on eliminated CPSSs. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration near its RBC (e.g. within 10% of its RBC).

Background-related Risk

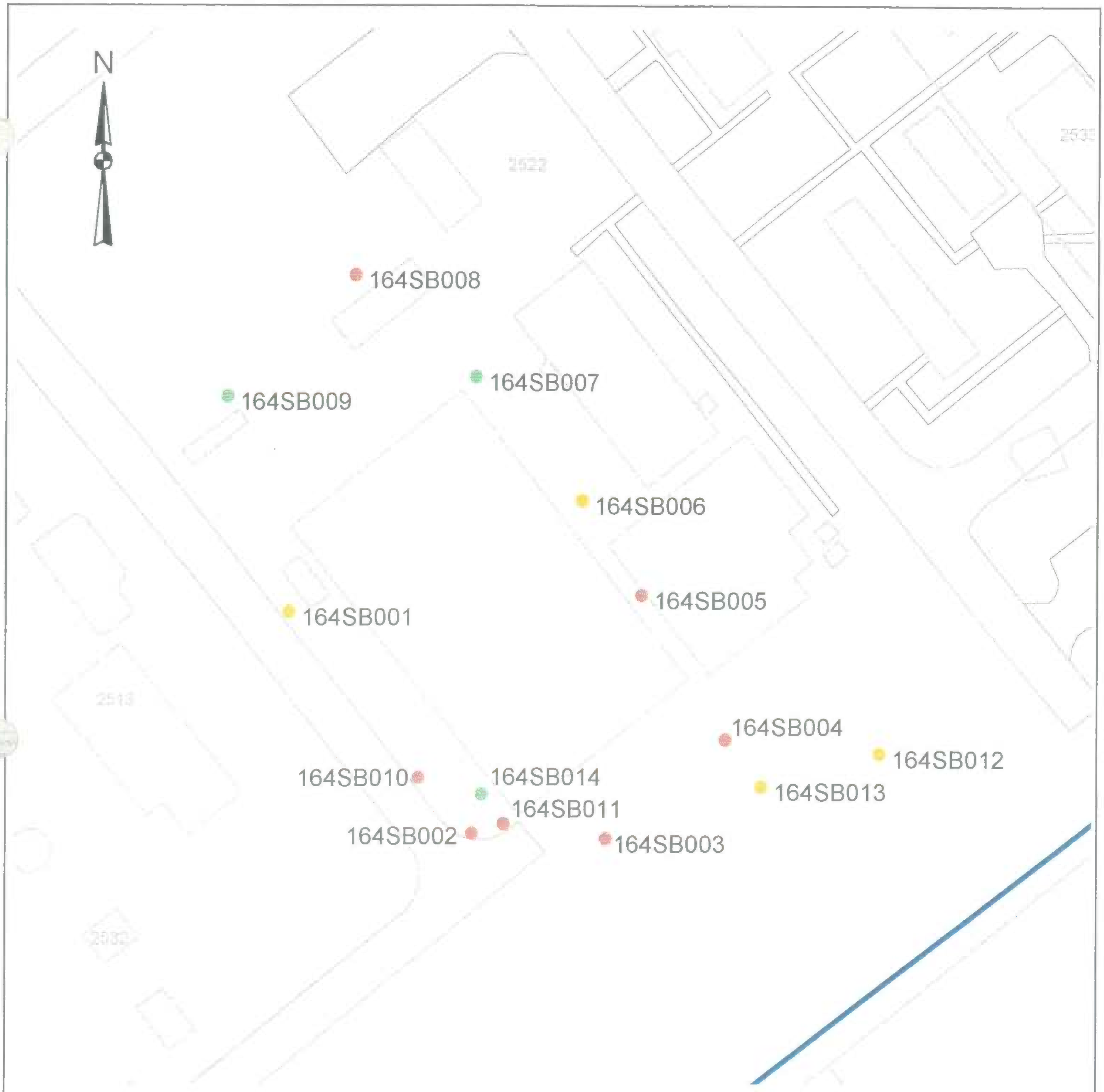
It is not unusual for naturally occurring or background concentrations of some elements to exceed risk-based concentrations. It is the risk assessment's function to identify excess risk and/or hazard, or that which exceeds background levels.

10.4.4.7 Risk Summary

The risk and hazard posed by contaminants at SWMU 164 were assessed for future site workers and future site residents under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Table 10.4.16 summarizes each pathway/receptor group evaluated for SWMU 164.

Soil — Residential Scenario

Residential soil pathway COCs identified for SWMU 164 are aluminum, arsenic, and benzo(a)pyrene equivalents. Figure 10.4.4 illustrates point risk estimates for SWMU 164 based



LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

50 0 50 100 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.4.4
SWMU 164

POINT RISK ESTIMATES FOR
SURFACE SOIL
RESIDENTIAL SCENARIO

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Table 10.4.16
Summary of Risk and Hazard
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.056	0.52	4E-05	0.020	5E-06
	Dermal Contact	0.011	0.038	1E-05	0.0082	4E-06
Sum of Soil Pathways		0.067	0.56	5E-05	0.028	9E-06

Notes:
ILCR Indicates incremental lifetime cancer risk
HI Indicates hazard index
LWA Lifetime-weighted average

Table 10.4.17
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
164	B001	Arsenic (As)	2.05	MG/KG	0.0937	48.13	5.3546	100.00
164	B001	B(a)P Equiv.	ND	UG/KG	NA		NA	
164	B001	Aluminum (Al)	7365	MG/KG	0.1010	51.87	NA	
		Total			0.1947		5.3546	
164	B002	Arsenic (As)	22.5	MG/KG	1.0284	91.32	58.7700	100.00
164	B002	B(a)P Equiv.	ND	UG/KG	NA		NA	
164	B002	Aluminum (Al)	7130	MG/KG	0.0978	8.68	NA	
		Total			1.1262		58.7700	
164	B003	Arsenic (As)	4.1	MG/KG	0.1874	70.42	10.7092	100.00
164	B003	B(a)P Equiv.	ND	UG/KG	NA		NA	
164	B003	Aluminum (Al)	5740	MG/KG	0.0787	29.58	NA	
		Total			0.2661		10.7092	
164	B004	Arsenic (As)	3.5	MG/KG	0.1600	67.29	9.1420	26.95
164	B004	B(a)P Equiv.	1496	UG/KG	NA		24.7742	73.05
164	B004	Aluminum (Al)	5670	MG/KG	0.0777	32.71	NA	
		Total			0.2377		33.9162	
164	B005	Arsenic (As)	5	MG/KG	0.2285	66.92	13.0600	73.00
164	B005	B(a)P Equiv.	291.68	UG/KG	NA		4.8303	27.00
164	B005	Aluminum (Al)	8240	MG/KG	0.1130	33.08	NA	
		Total			0.3415		17.8903	
164	B006	Arsenic (As)	2.5	MG/KG	0.1143	57.50	6.5300	100.00
164	B006	B(a)P Equiv.	ND	UG/KG	NA		NA	
164	B006	Aluminum (Al)	6160	MG/KG	0.0845	42.50	NA	
		Total			0.1987		6.5300	
164	B007	Arsenic (As)	1.8	MG/KG	0.0823	52.96	4.7016	100.00
164	B007	B(a)P Equiv.	ND	UG/KG	NA		NA	
164	B007	Aluminum (Al)	5330	MG/KG	0.0731	47.04	NA	
		Total			0.1554		4.7016	
164	B008	Arsenic (As)	2.4	MG/KG	0.1097	62.89	6.2688	59.31
164	B008	B(a)P Equiv.	259.74	UG/KG	NA		4.3014	40.69
164	B008	Aluminum (Al)	4720	MG/KG	0.0647	37.11	NA	
		Total			0.1744		10.5702	
164	B009	Arsenic (As)	1.1	MG/KG	0.0503	35.03	2.8732	95.33

Table 10.4.17
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
164	B009	B(a)P Equiv.	8.5	UG/KG	NA		0.1408	4.67
164	B009	Aluminum (Al)	6800	MG/KG	0.0932	64.97	NA	
		Total			0.1435		3.0140	
164	B010	Arsenic (As)	16.1	MG/KG	0.7359	100.00	42.0532	100.00
		Total			0.7359		42.0532	
164	B011	Arsenic (As)	7.9	MG/KG	0.3611	100.00	20.6348	100.00
		Total			0.3611		20.6348	
164	B012	Arsenic (As)	2.3	MG/KG	0.1051	47.39	6.0076	100.00
164	B012	B(a)P Equiv.	ND	UG/KG	NA		NA	
164	B012	Aluminum (Al)	8510	MG/KG	0.1167	52.61	NA	
		Total			0.2218		6.0076	
164	B013	Arsenic (As)	2.4	MG/KG	0.1097	49.08	6.2688	100.00
164	B013	B(a)P Equiv.	ND	UG/KG	NA		NA	
164	B013	Aluminum (Al)	8300	MG/KG	0.1138	50.92	NA	
		Total			0.2235		6.2688	
164	B014	Arsenic (As)	1.1	MG/KG	0.0503	100.00	2.8732	100.00
		Total			0.0503		2.8732	

on soil exposure pathways under a future residential scenario. Table 10.4.17 summarizes the risk and hazard contribution of each COPC at each sample location. This point risk map is based on the unlikely assumption that a potential future site resident would be chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of uniform exposure to the soil conditions of the entire site (or exposure unit area) rather than specific points. With this in mind, risk maps supplemented by the tables help the reader visualize how chemicals driving risk estimates are spatially distributed across the site.

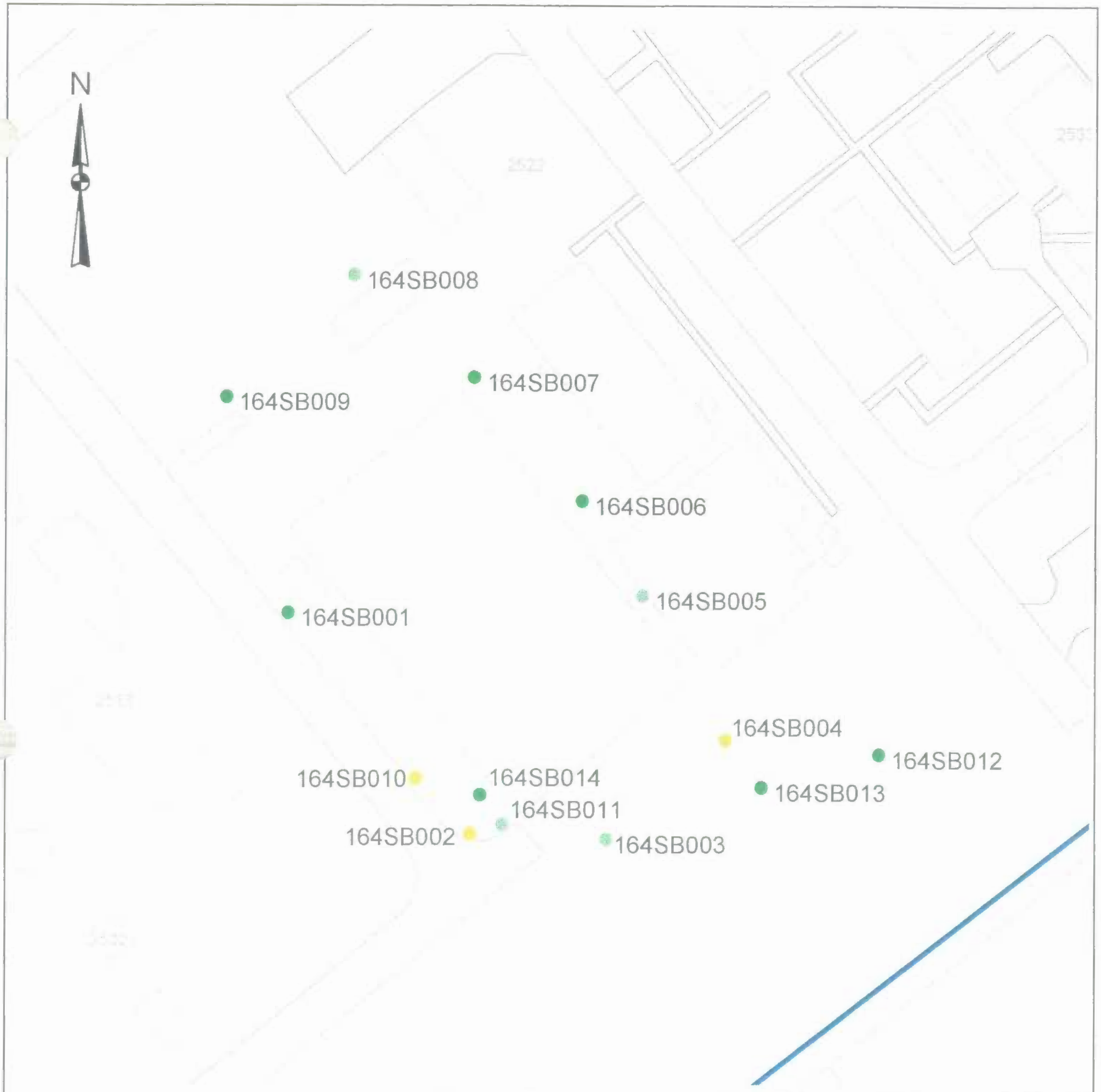
Arsenic contributed to risk estimates exceeding 1E-06 at all 14 surface soil sample locations. Benzo(a)pyrene equivalents contributed to risk estimates exceeding 1E-06 at three locations – 164SB004, 164SB005, and 164SB008. Risk estimates ranged from 3E-06 (164SB014) to 6E-05 (164SB002) with a mean risk estimate is 2E-05.

Arsenic contributed to a hazard index estimate exceeding unity at only one surface soil location (164SB002). Hazard estimates ranged from 0.05 (164SB014) to 1 (164SB002). The mean hazard estimate is 0.3.

Soil — Site Worker Scenario

Benzo(a)pyrene equivalents and arsenic were the only site worker soil pathway COCs identified for SWMU 164. Figure 10.4.5 illustrates point risk for the soil pathways under the industrial (site worker) scenario. As shown on Table 10.4.18 arsenic was the most widespread COC, contributing to a risk of 1E-06 at only one location (164SB004). Risk estimates ranged from 4E-07 (164SB014) to 8E-06 (164SB002) with a mean risk of 2E-06.

Hazard index projections did not exceed unity at any sample location. Hazard index estimates ranged from 0.002 (164SB0014) to 0.05 (164SB002).



LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

50 0 50 100 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.4.5
SWMU 164

POINT RISK ESTIMATES FOR
SURFACE SOIL
INDUSTRIAL SCENARIO

G:\Navy\Cto-029\Zone-k\Rfi-rpts\ArcView\risk maps.apr

Table 10.4.18
Point Estimates of Risk and Hazard - Surface Soil Pathways
Industrial Scenario
SWMU 164
Naval Base Charleston, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
164	B001	Arsenic (As)	2.05	MG/KG	0.0047	48.13	0.7575	100.00
164	B001	Aluminum (Al)	7365	MG/KG	0.0051	51.87	NA	
164	B001	B(a)P Equiv.	ND	UG/KG	NA		NA	
		Total			0.0098		0.7575	
164	B002	Arsenic (As)	22.5	MG/KG	0.0517	91.32	8.3139	100.00
164	B002	Aluminum (Al)	7130	MG/KG	0.0049	8.68	NA	
164	B002	B(a)P Equiv.	ND	UG/KG	NA		NA	
		Total			0.0567		8.3139	
164	B003	Arsenic (As)	4.1	MG/KG	0.0094	70.42	1.5150	100.00
164	B003	Aluminum (Al)	5740	MG/KG	0.0040	29.58	NA	
164	B003	B(a)P Equiv.	ND	UG/KG	NA		NA	
		Total			0.0134		1.5150	
164	B004	Arsenic (As)	3.5	MG/KG	0.0080	67.29	1.2933	20.43
164	B004	Aluminum (Al)	5670	MG/KG	0.0039	32.71	NA	
164	B004	B(a)P Equiv.	1496	UG/KG	NA		5.0372	79.57
		Total			0.0120		6.3305	
164	B005	Arsenic (As)	5	MG/KG	0.0115	66.92	1.8475	65.29
164	B005	Aluminum (Al)	8240	MG/KG	0.0057	33.08	NA	
164	B005	B(a)P Equiv.	291.68	UG/KG	NA		0.9821	34.71
		Total			0.0172		2.8297	
164	B006	Arsenic (As)	2.5	MG/KG	0.0057	57.50	0.9238	100.00
164	B006	Aluminum (Al)	6160	MG/KG	0.0042	42.50	NA	
164	B006	B(a)P Equiv.	ND	UG/KG	NA		NA	
		Total			0.0100		0.9238	
164	B007	Arsenic (As)	1.8	MG/KG	0.0041	52.96	0.6651	100.00
164	B007	Aluminum (Al)	5330	MG/KG	0.0037	47.04	NA	
164	B007	B(a)P Equiv.	ND	UG/KG	NA		NA	
		Total			0.0078		0.6651	
164	B008	Arsenic (As)	2.4	MG/KG	0.0055	62.89	0.8868	50.35
164	B008	Aluminum (Al)	4720	MG/KG	0.0033	37.11	NA	
164	B008	B(a)P Equiv.	259.74	UG/KG	NA		0.8746	49.65
		Total			0.0088		1.7614	
164	B009	Arsenic (As)	1.1	MG/KG	0.0025	35.03	0.4065	93.42

Table 10.4.18
Point Estimates of Risk and Hazard - Surface Soil Pathways
Industrial Scenario
SWMU 164
Naval Base Charleston, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
164	B009	Aluminum (Al)	6800	MG/KG	0.0047	64.97	NA	
164	B009	B(a)P Equiv.	8.5	UG/KG	NA		0.0286	6.58
		Total			0.0072		0.4351	
164	B010	Arsenic (As)	16.1	MG/KG	0.0370	100.00	5.9491	100.00
		Total			0.0370		5.9491	
164	B011	Arsenic (As)	7.9	MG/KG	0.0182	100.00	2.9191	100.00
		Total			0.0182		2.9191	
164	B012	Arsenic (As)	2.3	MG/KG	0.0053	47.39	0.8499	100.00
164	B012	Aluminum (Al)	8510	MG/KG	0.0059	52.61	NA	
164	B012	B(a)P Equiv.	ND	UG/KG	NA		NA	
		Total			0.0112		0.8499	
164	B013	Arsenic (As)	2.4	MG/KG	0.0055	49.08	0.8868	100.00
164	B013	Aluminum (Al)	8300	MG/KG	0.0057	50.92	NA	
164	B013	B(a)P Equiv.	ND	UG/KG	NA		NA	
		Total			0.0112		0.8868	
164	B014	Arsenic (As)	1.1	MG/KG	0.0025	100.00	0.4065	100.00
		Total			0.0025		0.4065	

10.4.4.8 Remedial Goal Options

Soil

RGOs for carcinogens were based on the lifetime-weighted average site resident or site worker as presented in Table 10.4.19 for surface soils. Hazard-based RGOs were based on the hypothetical child resident or site worker, as noted in the table.

10.4.5 Corrective Measures Considerations

For SWMU 164, the upper and lower soil intervals were investigated. In all, 14 soil samples each were collected from the upper- and lower-intervals. Based on the analytical results and the human health risk assessment, COCs requiring further evaluation through the CMS process were identified for the upper-interval soil.

Benzo(a)pyrene equivalents, aluminum, and arsenic were identified as COCs in the upper soil interval. BEQs exceeded the residential RBC in three of the surface soil samples collected. Arsenic exceeded its RBC (0.43 mg/kg) in all 14 surface soil samples. Aluminum concentrations did not exceed its RBC at any location. The soil pathway cumulative residential exposure risk is 5E-05 and the cumulative HI is 0.56 (resident child). Both are between USEPA's acceptable range of 1E-06 and 1E-04 for risk and 3 and 0.1 for HI.

Residential risk-based remedial goals for surface soil set for BEQs and arsenic were 0.06 and 0.38 mg/kg, respectively, based on a target risk of 1E-06. Potential corrective measures are presented in Table 10.4.20.

Table 10.4.19
Remedial Goal Options for Soil
SWMU 164
Charleston Naval Complex, Zone K
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Inorganics										
Arsenic (As)	1.5	0.0003	9.96	66	22	2.2	0.38	3.8	38	3
Semivolatile Organics										
Benzo(a)pyrene equivalents	7.3	NA	1.5	ND	ND	ND	0.06	0.6	6	NA

Worker-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options 3 mg/kg	1 mg/kg	0.1 mg/kg	Risk-Based Remedial Goal Options 1E-06 mg/kg	1E-05 mg/kg	1E-04 mg/kg	Background Concentration mg/kg
Inorganics										
Arsenic (As)	1.5	0.0003	10.0	1305	435	43	2.7	27	271	3
Semivolatile Organics										
Benzo(a)pyrene equivalents	7.3	NA	1.5	ND	ND	ND	0.30	3.0	30	NA

NOTES:
EPC Exposure point concentration
NA Not applicable
ND Not determined
Remedial goal options were based on the residential or site worker lifetime-weighted average for carcinogens and the child resident or site worker for noncarcinogens.

Table 10.4.20
Potential Corrective Measures for SWMU 164

Medium	Compounds	Potential Corrective Measures
Soil	Alumimum, arsenic and benzo(a)pyrene equivalents	a) No action b) Intrinsic remediation and monitoring c) Containment by capping d) Excavation and landfill, if RCRA nonhazardous waste e) Insitu, chemical and physical treatment f) Exsitu, chemical and physical treatment

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10.5 SWMU 185, Sewer System and Former Septic Tank System, Naval Annex

The CSI report for SWMU 185, formerly known as SWMU 166, was submitted as an addendum along with SWMU 166, the Automotive Repair Shop in November 1998. The revised Section 10.5 will be included with this Final RFI report following completion of the SWMU 166 investigation and review of the addendum.

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10.6 AOC 693, Fuse and Primer House, Former Building 117 and AOC 694, Former Naval Ammunition Depot

Due to their proximity and similar histories, AOCs 693 and 694 were investigated together. AOC 694 encompasses the area of AOC 693 (Figure 10.6.1). Portions of the multiple-site sampling plan were AOC-specific.

AOC 693 consists of former Building 117, a two room fuse and primer house, which operated from 1930 until 1939. It is located in a wooded area adjacent to the Clouter Creek Dredge Area on Clouter Island. No visual evidence of past operations is present in the building. No other information was identified pertaining to the design features or operating practices of this fuse and primer house.

AOC 694, a former Naval Ammunition Depot in operation from the 1920s until the 1940s, consists of the area surrounding former Building 117. The exact location and dimensions of this former explosives storage area are not known. Dredged materials may have been deposited in this area since its use as an ammunition depot was discontinued. No other information was identified pertaining to the design features or operating practices of this facility.

The remnants of three other structures also remain within the former depot. The northernmost structure along the river shoreline is the foundation of Building 106, the Fixed Ammo Storehouse. Approximately 200 feet south of Building 106, also at the shoreline, is the foundation of Building 102, the Shell House. The only other foundation observed in the depot is between Building 102 and the intact Fuse and Primer House (Building 115; AOC 693). This is the former site of Building 103, the Magazine, which is also near the shore, but completely within the wooded bottomland.

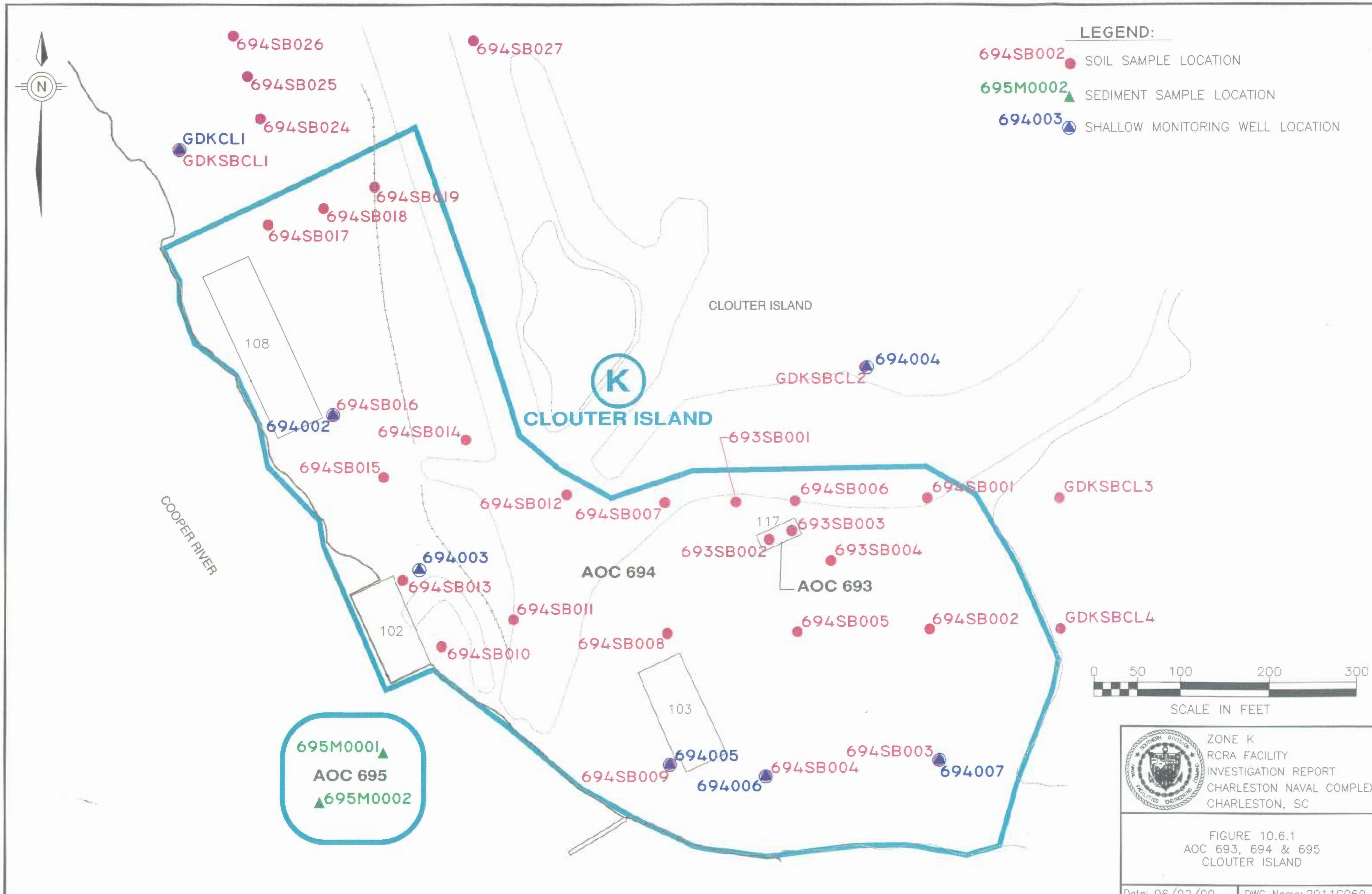
Three distinct ecological subzones were identified in association with the Naval Depot. These include a narrow salt marsh in the at the water's edge (K-1), a wooded bottomland (K-2) which is dominated by hackberry trees, and a scrub/shrub community (K-3) along the perimeter of the dike and at the outer edge of K-2. Figure 8.2A presents the locations and areal extent of these various habitats with respect to the Clouter Island AOCs.

According to construction details of the Dredge Disposal Area at Clouter Island, nine dewatering spillways discharge from the shore opposite the AOCs and into Clouter Creek. No impact to the Zone K AOCs is anticipated from these spillways.

Waste materials associated with the former ammunition depot include military explosives. Based on their toxicity characteristic, some explosives contain leachable concentrations of metals. Historically, primer components may have included antimony, barium, lead, or mercury. A survey conducted by an unexploded ordnance subcontractor was completed prior to initiating any sample collection effort at AOCs 693 and 694. The survey was designed to identify the presence of unexploded ordnance from ground surface to a depth of 5 feet bgs throughout the AOCs 693 and 694 area illustrated on Figure 10.6.1. Material of an unknown origin was also reported in the AOC 694 area (verbal communication with Doyle Brittain, CNC RPM, Region IV U.S. EPA, February 7, 1996, Zone K Scoping Meeting).

Materials of concern identified in the final RFI work plan (E/A&H, September 1996) for AOCs 693 and 694 are metals and explosives. Potential receptors are current and future site users involved in invasive activities.

To fulfill CSI objectives, soil and groundwater were sampled in accordance with the final RFI work plan and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at AOCs 693 and 694.



LEGEND:
694SB002 SOIL SAMPLE LOCATION
695M0002 SEDIMENT SAMPLE LOCATION
694003 SHALLOW MONITORING WELL LOCATION
N
694SB026
694SB027
694SB025
694SB024
GDKCL1
GDKSBCL1
694SB019
694SB018
694SB017
108
CLOUTER ISLAND
694004
GDKSBCL2
K
CLOUTER ISLAND
694SB016
694002
694SB014
693SB001
694SB015
694SB006
694SB001
GDKSBCL3
694SB012
694SB007
117
693SB003
COOPER RIVER
693SB002
693SB004
694003
AOC 694
694SB013
AOC 693
694SB011
694SB005
694SB002
GDKSBCL4
102
694SB008
694SB010
0 50 100 200 300
SCALE IN FEET
103
695M0001
AOC 695
695M0002
694005
694SB009
694006
694SB004
694SB003
694007
ZONE K
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.6.1
AOC 693, 694 & 695
CLOUTER ISLAND
Date: 06/02/99
DWG Name: 2911C069

00149T112

10.6.1 Soil Sampling and Analysis

Soil was sampled in two rounds at AOCs 693 and 694 from the locations shown on Figure 10.6.1. The final RFI work plan proposed collection of 23 soil samples from the upper-interval (0 to 1 foot) and 23 from the lower-interval (3 to 5 feet) for the AOCs 693 and 694 investigation area. During round one in January 1997, the proposed 23 samples were collected from the upper-interval, but only nine were collected from the lower-interval due to a water table less than 5 feet bgs. Saturated samples were not submitted for analysis. Only one of the four proposed subsurface background soil samples was collected due to the shallow depth to groundwater. Round two, performed in January 1999, included the collection of four additional upper-interval samples and three additional lower-interval samples.

First-round samples were submitted for Appendix IX analyses at DQO Level IV. One duplicate sample was collected from boring 693SB001's upper-interval and submitted for Appendix IX analyses at DQO Level IV. Round two samples were submitted for dioxin and metals analysis only. Table 10.6.1 summarizes soil sampling for AOCs 693 and 694.

Table 10.6.1
AOCs 693 and 694
Soil Sampling Summary

Sampling Round	Sampling Date	Samples Collected	Sample Analyses	Comments
1	1/14-17/97	Upper - 23 (23) Lower - 9 (23) Duplicate - 1	Appendix IX plus explosives	None
2	1/13/99	Upper - 4 (0) Lower - 4 (0)	Dioxins and metals	Shallow water table prevented collection of majority of second interval samples as saturated samples were not submitted for analysis.

Notes:
( ) = Parentheses indicate number of samples proposed in the RFI work plan.
Appendix IX = VOCs, SVOCs, metals, cyanides, pesticides, PCBs, hex-chrome, dioxins, herbicides, and OP pesticides at DQO Level IV.

10.6.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.6.2. Inorganic analytical results are summarized in Table 10.6.3. Table 10.6.4 summarizes all analytes detected in soil at AOCs 693 and 694. Analyte concentrations are listed in bold if they exceeded their respective screening concentrations, the applicable residential soil RBC or SSL and, when available, the associated background concentration. Appendix F is a complete analytical data report for all samples collected in Zone K, including AOCs 693 and 694.

Table 10.6.2
AOCs 693 and 694
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Volatile Organic Compounds ($\mu g/kg$) (32 samples collected, 23 upper, 9 lower, 1 duplicate for Appendix IX analysis						
Acetone	Upper	1/23	2	2	780,000	0
	Lower	0/9	ND	ND	8,000	0
2-Butanone (MEK)	Upper	0/23	ND	ND	4,700,000	0
	Lower	1/9	7	7	3,900	NA
Carbon disulfide	Upper	1/23	4	4	780,000	0
	Lower	0/9	ND	ND	16,000	0
Semivolatile Organic Compounds ($\mu g/kg$) (32 samples collected, 23 upper, 9 lower, 1 duplicate for Appendix IX analysis)						
BEQs	Upper	6/23	18.8 - 535.5	246	87	5
	Lower	1/9	99.1 - 513.6	306	4,000	0
Benzo(a)anthracene	Upper	4/23	87 - 480	264.25	870	0
	Lower	1/9	170	170	800	0
Benzo(a)pyrene	Upper	5/23	89 - 440	234	87	5
	Lower	2/9	87 - 410	248.5	4,000	0
Benzo(b)fluoranthene	Upper	6/23	100 - 450	272	870	0
	Lower	2/9	120 - 590	355	2,300	0
Benzo(k)fluoranthene	Upper	4/23	130 - 180	158	8,700	0
	Lower	1/9	140	140	25,000	0
Chrysene	Upper	6/23	99 - 660	260	87,000	0
	Lower	2/9	88 - 240	164	80,000	0

Table 10.6.2
AOCs 693 and 694
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Indeno(1,2,3-cd)pyrene	Upper	2/23	130 - 160	145	870	0
	Lower	1/9	260	260	7,000	0
Anthracene	Upper	1/23	110	110	2,300,000	0
	Lower	0/9	ND	ND	6,000,000	0
Benzo(g,h,i)perylene	Upper	1/23	180	180	160,000	0
	Lower	1/9	280	280	57,000,000	0
bis(2-Ethylhexyl)phthalate	Upper	2/23	420 - 620	520	4,600	0
	Lower	1/9	490	490	1,800,000	0
Butylbenzylphthalate	Upper	1/23	680	680	1,600,000	0
	Lower	0/9	ND	ND	930,000	0
Fluoranthene	Upper	5/23	87 - 710	317	310,000	0
	Lower	1/9	230	230	2,210,000	0
Phenanthrene	Upper	2/23	140 - 750	445	160,000	0
	Lower	0/9	ND	ND	660,000	NA
Pyrene	Upper	6/23	91 - 1100	362	230,000	0
	Lower	2/9	100 - 300	200	2,100,000	0
Pesticides/PCBs (μg/kg) **(32 samples collected, 23 upper, 9 lower, 1 duplicate for Appendix IX analysis)**						
Aldrin	Upper	2/23	3.03 - 8.44	6	38	0
	Lower	1/9	2.59	2.59	200	0
Aroclor-1260	Upper	14/22	26 - 596	112	320	1
	Lower	6/9	66.7 - 155	94.8	1,000	0
delta-BHC	Upper	1/23	2.62	2.62	NL	0
	Lower	0/9	ND	ND	1.8	0
alpha-Chlordane	Upper	1/23	9.91	9.91	1,800[a]	0
	Lower	0/9	ND	ND	5,000	0
Dieldrin	Upper	3/23	3.89 - 9.2	7.1	40	0
	Lower	1/9	4.82	4.82	2.0	1
4,4'-DDD	Upper	3/23	4.74 - 54.8	22	2,700	0
	Lower	1/9	6.43	6.43	8,000	0
4,4'-DDE	Upper	3/23	4.72 - 14	9	1,900	0
	Lower	0/9	ND	ND	27,000	0
4,4'-DDT	Upper	3/23	14.3 - 70	34.4	1,900	0
	Lower	1/9	58.8	58.8	16,000	0

Table 10.6.2
AOCs 693 and 694
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Endrin	Upper	5/22	5.2 - 36.2	12.6	2,300	0
	Lower	3/9	5.02 - 12.6	8.4	500	0
Endrin aldehyde	Upper	2/23	6 - 20.9	13.45	2,300	0
	Lower	1/9	4.79	4.79	340	0
Heptachlor epoxide	Upper	7/23	2.56 - 54.7	16.4	70	0
	Lower	1/9	2.89	2.89	330	0
Dioxins (ng/kg) (39 samples collected, 27 upper, 12 lower, 1 duplicate for Appendix IX analysis)						
TCDD TEQ	Upper	27/27	5.7E-03 - 9.5	1.96	4.3	3
	Lower	12/12	3.0E-03 - 2.6	.756	1,600	0

Notes:
a = RBC for chlordane was used as a surrogate for alpha-chlordane.
b = RBC for endosulfan was used as a surrogate for endosulfan II.
ND = Not detected/not determined
NA = Not applicable/not available/not analyzed
NL = Not listed

Table 10.6.3
AOCs 693 and 694
Inorganics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples[b] Exceeding: RBC and Background (upper) or SSL and Background (lower)
Inorganics (mg/kg) 32 samples collected; 27 upper-interval samples, 12 lower-interval samples, 1 duplicate for Appendix IX analyses							
Aluminum	Upper	27/27	1,370 - 44,700	19,954	32,100	7,800	5
	Lower	12/12	4,460 - 38,500	14,252	NA	560,000	0
Antimony	Upper	17/27	0.56 - 27.9	3.42	2.16	3.1	5
	Lower	7/12	0.36 - 4.7	1.77	NA	2.7	1
Arsenic	Upper	25/27	7.2 - 25.8	13.9	23.0	0.43[a]	1
	Lower	12/12	5.3 - 21.6	10	NA	15	2
Barium	Upper	27/27	4.9 - 131	35.2	67.1	550	0
	Lower	12/12	8.7 - 44.6	25.1	NA	820	0

Table 10.6.3
AOCs 693 and 694
Inorganics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range			Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples[b] Exceeding: RBC and Background (upper) or SSL and Background (lower)
Beryllium	Upper	27/27	0.1	-	1.6	0.9	1.35	16	0
	Lower	12/12	0.34	-	1.5	0.68	NA	32	0
Cadmium	Upper	23/27	0.22	-	1.5	0.4	0.55	3.9	0
	Lower	10/12	0.19	-	1.1	0.44	NA	4.0	0
Calcium	Upper	27/27	4,470	-	100,000	36,937	NA	NL	NA
	Lower	12/12	18,500	-	239,000	111,883	NA	NL	NA
Chromium	Upper	27/27	4.8	-	77.3	48.3	69.1	12,000	0
	Lower	12/12	14.4	-	64.0	42.1	NA	1,000,000	0
Cobalt	Upper	27/27	0.97	-	10.1	4.96	5.7	470	0
	Lower	11/12	1	-	11.7	3.7	NA	990	0
Copper	Upper	27/27	4.3	-	1020	89.9	119	310	1
	Lower	12/12	10.9	-	126	56.7	NA	5,600	0
Iron	Upper	27/27	2,170	-	43,200	23,232	35,200	2300	3
	Lower	12/12	4,770	-	37,200	14,814	NA	NL	NA
Lead	Upper	27/27	5.3	-	481	84.2	98.3	400*	1
	Lower	12/12	3.2	-	106	51.1	NA	400**	0
Magnesium	Upper	27/27	355	-	6,700	3,786	NA	NL	NA
	Lower	12/12	1,390	-	9,180	4,724	NA	NL	NA
Manganese	Upper	27/27	83.5	-	738	381	1210	160	0
	Lower	12/12	90.6	-	747	279	NA	480	1
Mercury	Upper	25/27	0.11	-	1.7	0.36	0.63	2.3	0
	Lower	11/12	0.07	-	1.4	0.34	NA	1.0	1
Nickel	Upper	27/27	1.7	-	37.1	16.8	24.5	160	0
	Lower	12/12	4.7	-	22.5	16.5	NA	65	0
Potassium	Upper	27/27	172	-	5,800	1,981	NA	NL	NA
	Lower	12/12	514	-	4,090	1,636	NA	NL	NA
Selenium	Upper	9/27	0.69	-	4.7	1.58	1.24	39	0
	Lower	2/12	0.82	-	1.3	1.06	NA	2.6	0
Silver	Upper	15/27	0.31	-	1.2	0.6	0.41	39	0
	Lower	1/12		0.33		0.33	NA	17	0

Table 10.6.3
AOCs 693 and 694
Inorganics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range			Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples[b] Exceeding: RBC and Background (upper) or SSL and Background (lower)
Sodium	Upper	27/27	167	-	5,130	1,132	NA	NL	NA
	Lower	12/12	218	-	12,200	2,731	NA	NL	NA
Tin	Upper	14/27	5.9	-	284	53.6	39.1	4,700	0
	Lower	5/12	7.5	-	73.3	27.6	NA	5,500	0
Vanadium	Upper	27/27	4.3	-	92.2	47.5	75.9	55	3
	Lower	12/12	17.6	-	81.4	36.1	NA	3,000	0
Zinc	Upper	26/27	38.9	-	792	210	236	2,300	0
	Lower	12/12	48.6	-	341	177	NA	6,200	0

Notes:
Background concentration calculated for upper-interval only. Only one background lower-interval sample collected.
a = RBC for arsenic as a carcinogen.
b = Number of samples exceeding both the RBC and background for upper-interval samples or the SSL and background for lower-interval samples.
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed
* = RBC not available for lead. USEPA residential soil cleanup level used for comparison (OSWER Directive 9355.4-12).
** = SSL value not based on target leachate concentration.

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Volatile Organic Compounds (μg/kg)							
Acetone	694SB015	2	780,000	NA	ND	8,000	NA
2-Butanone (MEK)	694SB008	ND	4,700,000	NA	7	3,900	NA
Carbon disulfide	694SB010	4	780,000	NA	NT	16,000	NA
Semivolatile Organic Compounds (μg/kg)							
BEQs	694SB003	**120**	87	NA	NT	4,000	NA
	694SB009	**359**			ND		
	694SB011	ND			514		
	694SB012	ND			99		
	694SB013	**535**			NT		
	694SB016	**105**			ND		
	694SB018	**337**			NT		
	694SB019	18.8			NT		
Benzo(a)anthracene	694SB009	250	870	NA	ND	800	NA
	694SB011	ND			170		
	694SB013	480			NT		
	694SB018	240			NT		
	694SB019	87			NT		
Benzo(a)pyrene	694SB003	**100**	87	NA	NT	4,000	NA
	694SB009	**280**			ND		
	694SB011	ND			410		
	694SB012	ND			87		
	694SB013	**440**			NT		
	694SB016	**89**			ND		
	694SB018	**260**			NT		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Benzo(b)fluoranthene	694SB003	200	870	NA	NT	2,300	NA
	694SB009	390			ND		
	694SB011	ND			590		
	694SB012	ND			120		
	694SB013	450			NT		
	694SB016	140			ND		
	694SB018	350			NT		
	694SB019	100			NT		
Benzo(k)fluoranthene	694SB009	150	8,700	NA	ND	25,000	NA
	694SB011	ND			140		
	694SB013	180			NT		
	694SB016	170			ND		
	694SB018	130			NT		
Chrysene	694SB003	130	87,000	NA	NT	80,000	NA
	694SB009	300			ND		
	694SB011	ND			240		
	694SB012	ND			88		
	694SB013	660			NT		
	694SB016	99			ND		
	694SB018	270			NT		
	694SB019	100			NT		
Indeno(1,2,3-cd)pyrene	694SB009	130	870	NA	ND	7,000	NA
	694SB011	ND			260		
	694SB018	160			NY		
Anthracene	694SB013	110	2,300,000	NA	NT	6,000,000	NA
Benzo(g,h,i)perylene	694SB011	ND	160,000	NA	280	57,000,000	NA
	694SB018	180			NT		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
bis(2-Ethylhexyl)phthalate (BEHP)	694SB009	ND	4,600	NA	490	1,800,000	NA
	694SB014	620			NT		
	694SB019	420			NT		
Butylbenzylphthalate	694SB014	680	1,600,000		NT	930,000	
Fluoranthene	694SB009	230	310,000	NA	ND	2,100,000	NA
	694SB011	ND			230		
	694SB013	710			NT		
	694SB016	87			ND		
	694SB018	460			NT		
	694SB019	100			NT		
Phenanthrene	694SB013	750	160,000	NA	NT	660,000	NA
	694SB018	140			NT		
Pyrene	694SB003	110	230,000	NA	NT	2,100,000	NA
	694SB009	330			ND		
	694SB011	ND			300		
	694SB012	ND			100		
	694SB013	1,100			NT		
	694SB016	110			ND		
	694SB018	430			NT		
	694SB019	91			NT		
Pesticides/PCBs (μg/kg)							
4,4-DDD	694SB004	54.8	2,780	NA	NT	8,000	NA
	694SB008	ND			6.43		
	694SB009	4.74			ND		
	694SB011	5.88			ND		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
4,4-DDE	693SB001	14	1,900	NA	ND	27,000	NA
	694SB004	4.72			NT		
	694SB014	8.36			NT		
4,4-DDT	693SB001	70	1,900	NA	ND	16,000	NA
	694SB003	14.3			NT		
	694SB008	ND			58.8		
	694SB009	19			ND		
Aldrin	694SB012	3.03	38	NA	ND	200	NA
	694SB013	8.44			NT		
	694SB016	ND			2.59		
alpha-Chlordane	694SB014	9.91	1,800	NA	NT	5,000	NA
Aroclor-1260	693SB001	110	320	NA	ND	1,000	NA
	693SB002	40			NT		
	693SB003	52			NT		
	693SB004	48			NT		
	694SB005	50			NT		
	694SB006	26			NT		
	694SB007	170			110		
	694SB008	ND			80.5		
	694SB009	100			ND		
	694SB011	90.7			ND		
	694SB012	65.8			66.8		
	694SB014	**596**			NT		
	694SB015	73.3			66.7		
	694SB016	71.9			155		
	694SB017	74.8			89.8		
delta-BHC	694SB014	2.62	NL	NA	NT	1.8	NA

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Dieldrin	694SB011	ND	40	NA	**4.82**	2.0	NA
	694SB014	8.06			NT		
	694SB016	3.89			ND		
	694SB018	9.2			NT		
Endrin	694SB007	9.8	2,300	NA	ND	500	NA
	694SB012	5.2			ND		
	694SB014	36.2			NT		
	694SB015	5.28			5.02		
	694SB016	ND			12.6		
	694SB018	ND			7.61		
Endrin Aldehyde	694SB007	6	2,300	NA	ND	340	NA
	694SB014	20.9			NT		
	694SB016	ND			4.79		
Heptachlor epoxide	694SB001	7.2	70	NA	NT	330	NA
	694SB004	54.7			NT		
	694SB016	19.4			ND		
	694SB017	2.56			2.89		
	694SB018	7.76			NT		
	694SB019	6.97			NT		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Dioxin Compounds (ng/kg)							
TCDD TEQ	693SB001	2.081	4.3	NA	0.00304	1,600	NA
	693SB002	1.1723			NT		
	693SB003	0.37156			NT		
	693SB004	0.91529			NT		
	694SB001	0.00576			NT		
	694SB002	0.18895			NT		
	694SB003	0.26583			NT		
	694SB004	0.53771			NT		
	694SB005	0.42812			NT		
	694SB006	0.0332			NT		
	694SB007	1.11934			0.17698		
	694SB008	3.2058			0.50505		
	694SB009	1.6727			0.2161		
	694SB010	0.758616			NT		
	694SB011	1.5342			1.2428		
	694SB012	1.2645			2.6009		
	694SB013	0.471298			NT		
	694SB014	3.854			NT		
	694SB015	1.3366			0.69572		
	694SB016	2.6025			0.29582		
	694SB017	1.7769			1.954		
	694SB018	0.37035			NT		
	694SB019	1.0522			NT		
	694SB024	**7.314411**			0.090438		
	694SB025	**8.618577**			NT		
	694SB026	**9.456076**			0.447853		
	694SB027	0.661397			0.855223		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
1234678-HpCDD	693SB001	55.8	430	NA	ND	110,000	NA
	693SB002	31.8			NT		
	694SB002	9.37			NT		
	693SB003	11.8			NT		
	694SB003	10			NT		
	693SB004	30.1			NT		
	694SB004	17.2			NT		
	694SB005	23.2			NT		
	694SB006	2.26			NT		
	694SB007	44			10		
	694SB008	77.7			11.8		
	694SB009	42.7			3.36		
	694SB010	20.7			NT		
	694SB011	44.7			48.8		
	694SB012	39.2			61.6		
	694SB013	19.4			NT		
	694SB014	167			NT		
	694SB015	47.9			23.4		
	694SB016	72			10.5		
	694SB017	55.6			50.9		
	694SB018	10.6			NT		
	694SB019	37			NT		
	694SB024	197.731			3.44		
	694SB025	254.127			NT		
	694SB026	298.988			14.716		
	694SB027	26.06			31.986		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
1234678-HpCDF	693SB001	6.245	430	NA	ND	54,000	NA
	693SB002	3.98			NT		
	694SB002	1.92			NT		
	693SB003	1.74			NT		
	694SB003	1.87			NT		
	693SB004	3.14			NT		
	694SB004	2.51			NT		
	694SB005	2.61			NT		
	694SB007	6.31			0.968		
	694SB008	15.1			5.68		
	694SB009	9.24			1.4		
	694SB010	0.402			NT		
	694SB011	6.11			3.62		
	694SB012	4.54			10.3		
	694SB013	0.532			NT		
	694SB014	7.71			NT		
	694SB015	4.29			3.34		
	694SB016	10.2			4.37		
	694SB017	6.77			7.38		
	694SB018	7.73			NT		
	694SB019	3.82			NT		
	694SB024	26.333			0.49		
	694SB025	27.641			NT		
	694SB026	14.177			2.268		
	694SB027	ND			2.332		
1234789-HpCDF	694SB012	ND	NA	NA	0.79	540,000	NA
	694SB014	1.03			NT		
	694SB017	ND			2.17		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
123478-HxCDD	694SB008	1.72	43	NA	ND	4,100	NA
	694SB010	0.8889			NT		
	694SB026	1.209			ND		
123478-HxCDF	693SB001	3.37	43	NA	ND	220,000	NA
	693SB002	1.93			NT		
	693SB003	0.446			NT		
	694SB003	0.59			NT		
	693SB004	1.2			NT		
	694SB004	0.687			NT		
	694SB008	3.84			1.4		
	694SB009	1.77			1.39		
	694SB011	ND			0.898		
	694SB012	1.5			3.81		
	694SB014	4			NT		
	694SB015	1.46			1.16		
	694SB016	2.9			0.677		
	694SB017	2.22			2.54		
	694SB018	0.657			NT		
	694SB019	1.22			NT		
	694SB024	8.791			ND		
	694SB025	6.747			NT		
	694SB026	9.103			0.647		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
123678-HxCDD	693SB001	4.835	43	NA	ND	4,100	NA
	693SB002	1.95			NT		
	693SB003	0.693			NT		
	693SB004	0.989			NT		
	694SB004	1.49			NT		
	694SB007	3.73			ND		
	694SB008	7.91			0.877		
	694SB009	1.9			ND		
	694SB010	0.773			NT		
	694SB011	3.2			1.79		
	694SB012	1.93			5.76		
	694SB014	3.44			NT		
	694SB015	0.814			1.07		
	694SB016	5.33			ND		
	694SB017	3			3.6		
	694SB019	1.44			NT		
	694SB024	7.002			ND		
	694SB025	7.651			NT		
	694SB026	7.596			ND		
	694SB027	ND			0.967		
123678-HxCDF	694SB024	5.669	43	NA	ND	220,000	NA
	694SB025	2.004			NT		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
123789-HxCDD	693SB001	2.68	43	NA	ND	4,100	NA
	693SB002	1.77			NT		
	693SB004	1.23			NT		
	694SB008	3.56			ND		
	694SB009	2.16			ND		
	694SB010	1.98			NT		
	694SB011	2.13			1.8		
	694SB012	1.46			3.38		
	694SB013	1.12			NT		
	694SB014	2.88			NT		
	694SB015	2.01			ND		
	694SB016	3.91			ND		
	694SB017	2.05			2.5		
	694SB019	1.38			NT		
	694SB024	3.852			ND		
	694SB025	9.308			NT		
	694SB026	8.825			ND		
	694SB027	0.818			ND		
12378-PeCDF	694SB008	1.11	85	NA	ND	770	NA
	694SB011	1.65			ND		
	694SB024	1.62			ND		
	694SB025	0.585			NT		
	694SB026	1.716			ND		
2378-TCDD	694SB026	0.174	4.3	NA	ND	1,600	NA
2378-TCDF	694SB009	2.37	43	NA	ND	240	NA
	694SB024	0.965			ND		
	694SB025	0.77			NT		
	694SB027	0.8			ND		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
OCDD	693SB001	359	4,300	NA	3.04	1,100,000	NA
	694SB001	5.76			NT		
	693SB002	239			NT		
	694SB002	74.2			NT		
	693SB003	118			NT		
	694SB003	85			NT		
	693SB004	234			NT		
	694SB004	117			NT		
	694SB005	166			NT		
	694SB006	10.6			NT		
	694SB007	235			65.8		
	694SB008	492			96		
	694SB009	314			27.8		
	694SB010	183			NT		
	694SB011	396			257		
	694SB012	325			554		
	694SB013	159			NT		
	694SB014	1,030			NT		
	694SB015	376			197		
	694SB016	543			73.5		
	694SB017	410			467		
	694SB018	114			NT		
	694SB019	230			NT		
	694SB024	2,280.477			49.623		
	694SB025	2,983.754			NT		
	694SB026	3,312.714			204.774		
	694SB027	232.053			407.549		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
OCDF	693SB001	13.05	4,300	NA	ND	540,000	NA
	693SB002	10.5			NT		
	694SB002	1.85			NT		
	693SB003	4.26			NT		
	694SB003	3.13			NT		
	693SB004	6.99			NT		
	694SB004	5.91			NT		
	694SB005	4.02			NT		
	694SB007	8.24			1.5		
	694SB008	27.3			6.55		
	694SB009	19.3			1.7		
	694SB010	0.396			NT		
	694SB011	14.6			12.8		
	694SB012	13.1			25		
	694SB013	0.978			NT		
	694SB014	34.6			NT		
	694SB015	10.3			8.32		
	694SB016	23.5			5.92		
	694SB017	16.2			18.5		
	694SB018	7.35			NT		
	694SB019	10			NT		
	694SB024	84.394			1.515		
	694SB025	139.893			NT		
	694SB026	78.612			8.539		
	694SB027	6.944			7.794		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Inorganics (mg/kg)							
Aluminum (Al)	693SB001	**22,750**	7,800	32,100	4,460	560,000	NA
	694SB001	1,370			NT		
	693SB002	**39,000**			NT		
	694SB002	30,100			NT		
	693SB003	**39,100**			NT		
	694SB003	**33,100**			NT		
	693SB004	11,700			NT		
	694SB004	28,200			NT		
	694SB005	**44,700**			NT		
	694SB006	5,160			NT		
	694SB007	17,100			6,580		
	694SB008	**33,200**			27,600		
	694SB009	14,100			8,080		
	694SB010	21,400			NT		
	694SB011	17,000			9,070		
	694SB012	7,150			13,100		
	694SB013	17,900			NT		
	694SB014	6,720			NT		
	694SB015	12,400			7,170		
	694SB016	16,100			11,000		
	694SB017	12,300			5,230		
	694SB018	12,300			NT		
	694SB019	6,510			NT		
	694SB024	24,200			9,330		
	694SB025	17,000			NT		
	694SB026	20,100			30,900		
	694SB027	28,100			38,500		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Antimony (Sb)	693SB001	0.58	3.1	2.16	ND	2.7	NA
	694SB001	0.56			NT		
	693SB002	0.74			NT		
	694SB002	2.5			NT		
	694SB003	0.64			NT		
	694SB004	1			NT		
	694SB005	**3.3**			NT		
	694SB007	0.81			ND		
	694SB008	0.67			2.2		
	694SB009	**3.7**			1.4		
	694SB011	0.89			1.9		
	694SB012	**27.9**			0.36		
	694SB014	**5.6**			NT		
	694SB015	ND			0.7		
	694SB016	0.83			1.1		
	694SB017	1.1			NT		
	694SB018	2.2			NT		
	694SB019	**5.1**			NT		
	694SB026	ND			**4.7**		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Arsenic (As)	693SB001	17.5	0.43	23.0	8.1	15	NA
	693SB002	21.9			NT		
	694SB002	14.7			NT		
	693SB003	17.9			NT		
	694SB003	16.3			NT		
	693SB004	11.2			NT		
	694SB004	12.5			NT		
	694SB005	**25.8**			NT		
	694SB007	11.7			5.3		
	694SB008	16.5			**16.2**		
	694SB009	10.6			7.2		
	694SB010	21.5			NT		
	694SB011	12.1			8.6		
	694SB012	7.2			10		
	694SB013	17.4			NT		
	694SB014	12.1			NT		
	694SB015	8			8.3		
	694SB016	8.6			8.2		
	694SB017	9.7			6		
	694SB018	7.4			NT		
	694SB019	9			NT		
	694SB024	13.8			6.9		
	694SB025	12.4			NT		
	694SB026	13.5			13.2		
	694SB027	17.2			**21.6**		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Barium (Ba)	693SB001	41.8	550	67.1	8.7	820	NA
	694SB001	4.9			NT		
	693SB002	48.6			NT		
	694SB002	37.6			NT		
	693SB003	44.5			NT		
	694SB003	41.2			NT		
	693SB004	27.4			NT		
	694SB004	35.6			NT		
	694SB005	51			NT		
	694SB006	10.7			NT		
	694SB007	30.3			14.8		
	694SB008	40.7			37.2		
	694SB009	131			35.4		
	694SB010	28.7			NT		
	694SB011	26.8			16.3		
	694SB012	18.7			21		
	694SB013	33.4			NT		
	694SB014	27.6			NT		
	694SB015	23.9			19.7		
	694SB016	33.9			19.1		
	694SB017	25			11.6		
	694SB018	31.9			NT		
	694SB019	22			NT		
	694SB024	40.3			28.9		
	694SB025	27.5			NT		
	694SB026	28.1			44.6		
	694SB027	36.1			43.9		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Beryllium (Be)	693SB001	1.25	16	1.35	0.36	32	NA
	694SB001	0.1			NT		
	693SB002	1.6			NT		
	694SB002	0.97			NT		
	693SB003	1.6			NT		
	694SB003	1.3			NT		
	693SB004	0.74			NT		
	694SB004	1			NT		
	694SB005	1.6			NT		
	694SB006	0.41			NT		
	694SB007	0.83			0.38		
	694SB008	1.2			0.96		
	694SB009	0.98			0.47		
	694SB010	0.8			NT		
	694SB011	0.87			0.53		
	694SB012	0.39			0.57		
	694SB013	0.99			NT		
	694SB014	0.54			NT		
	694SB015	0.55			0.55		
	694SB016	0.73			0.57		
	694SB017	0.63			0.34		
	694SB018	0.68			NT		
	694SB019	0.75			NT		
	694SB024	1.2			0.67		
	694SB025	0.86			NT		
	694SB026	0.88			1.2		
	694SB027	1.2			1.5		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Cadmium (Cd)	693SB001	0.38	3.9	0.55	0.36	4	NA
	694SB002	0.32			NT		
	693SB003	0.32			NT		
	694SB003	0.25			NT		
	693SB004	0.23			NT		
	694SB004	0.39			NT		
	694SB005	0.28			NT		
	694SB006	0.22			NT		
	694SB007	0.26			0.48		
	694SB008	0.33			1.1		
	694SB009	1.1			0.58		
	694SB011	0.27			0.63		
	694SB012	0.57			0.3		
	694SB014	1.5			NT		
	694SB015	0.28			0.25		
	694SB016	0.24			NT		
	694SB017	0.24			NT		
	694SB018	0.52			NT		
	694SB019	0.52			NT		
	694SB024	0.56			0.19		
	694SB025	0.29			NT		
	694SB026	0.26			0.23		
	694SB027	0.25			0.32		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Calcium (Ca)	693SB001	26,750	NL	NA	230,000	NL	NA
	694SB001	6,220			NT		
	693SB002	7,840			NT		
	694SB002	39,000			NT		
	693SB003	7,470			NT		
	694SB003	7,530			NT		
	693SB004	10,700			NT		
	694SB004	33,800			NT		
	694SB005	8,770			NT		
	694SB006	50,500			NT		
	694SB007	27,800			239,000		
	694SB008	57,200			144,000		
	694SB009	26,000			168,000		
	694SB010	4,470			NT		
	694SB011	53,400			195,000		
	694SB012	100,000			89,500		
	694SB013	9,260			NT		
	694SB014	72,400			NT		
	694SB015	57,400			52,400		
	694SB016	45,700			86,500		
	694SB017	28,100			22,100		
	694SB018	42,400			NT		
	694SB019	46,300			NT		
	694SB024	92,500			18,500		
	694SB025	32,300			NT		
	694SB026	36,800			72,400		
	694SB027	66,700			25,200		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Chromium (Cr)	693SB001	57.1	23	69.1	40	1000000	NA
	694SB001	4.8			NT		
	693SB002	67.2			NT		
	694SB002	51.9			NT		
	693SB003	75			NT		
	694SB003	63			NT		
	693SB004	29.4			NT		
	694SB004	53.2			NT		
	694SB005	77.3			NT		
	694SB006	16.7			NT		
	694SB007	38.1			49.3		
	694SB008	59.7			63.8		
	694SB009	69.5			48.7		
	694SB010	48.7			NT		
	694SB011	55.7			46.7		
	694SB012	43.3			38.4		
	694SB013	41.2			NT		
	694SB014	63.9			NT		
	694SB015	29			22.9		
	694SB016	33.2			33.5		
	694SB017	30.6			14.4		
	694SB018	34.4			NT		
	694SB019	75			NT		
	694SB024	60.5			24.7		
	694SB025	35.8			NT		
	694SB026	38.6			58.7		
	694SB027	51.3			64		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Cobalt (Co)	693SB001	5.7	470	5.7	1.2	990	NA
	694SB001	0.97			NT		
	693SB002	7.6			NT		
	694SB002	5.1			NT		
	693SB003	7.7			NT		
	694SB003	6.9			NT		
	693SB004	3.4			NT		
	694SB004	5.8			NT		
	694SB005	10.1			NT		
	694SB006	1.4			NT		
	694SB007	4.1			ND		
	694SB008	5.7			3.6		
	694SB009	7.8			1		
	694SB010	3.7			NT		
	694SB011	3.9			1.2		
	694SB012	1.5			2.4		
	694SB013	5.3			NT		
	694SB014	5.3			NT		
	694SB015	2.6			1.7		
	694SB016	3.5			3.7		
	694SB017	3			1.2		
	694SB018	2.2			NT		
	694SB019	3			NT		
	694SB024	5.9			7.2		
	694SB025	5.4			NT		
	694SB026	6.6			5.9		
	694SB027	9.7			11.7		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Copper (Cu)	693SB001	38.4	310	119	11.4	5,600	NA
	694SB001	4.3			NT		
	693SB002	34.4			NT		
	694SB002	32.1			NT		
	693SB003	36.1			NT		
	694SB003	33.8			NT		
	693SB004	21.5			NT		
	694SB004	82.6			NT		
	694SB005	39.6			NT		
	694SB006	30.2			NT		
	694SB007	55.2			10.9		
	694SB008	48.6			110		
	694SB009	260			126		
	694SB010	11.2			NT		
	694SB011	60.8			64.9		
	694SB012	77.4			47.9		
	694SB013	14.8			NT		
	694SB014	**1,020**			NT		
	694SB015	41.1			42.6		
	694SB016	50			65.4		
	694SB017	57.7			21.6		
	694SB018	99.7			NT		
	694SB019	160			NT		
	694SB024	32.8			111		
	694SB025	28.8			NT		
	694SB026	26.7			35.1		
	694SB027	29.8			33		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Iron (Fe)	693SB001	30,150	2,300	35200	4,770	NL	NA
	694SB001	2,170			NT		
	693SB002	**43,200**			NT		
	694SB002	21,500			NT		
	693SB003	**37,200**			NT		
	694SB003	31,300			NT		
	693SB004	17,900			NT		
	694SB004	25,100			NT		
	694SB005	**40,700**			NT		
	694SB006	5,440			NT		
	694SB007	18,600			5,230		
	694SB008	29,700			22,500		
	694SB009	25,100			10,300		
	694SB010	33,700			NT		
	694SB011	19,300			9,310		
	694SB012	10,800			17,000		
	694SB013	27,600			NT		
	694SB014	28,100			NT		
	694SB015	13,300			10,900		
	694SB016	15,400			11,500		
	694SB017	17,900			8,360		
	694SB018	11,600			NT		
	694SB019	18,600			NT		
	694SB024	30,300			12,300		
	694SB025	20,800			NT		
	694SB026	22,300			28,400		
	694SB027	29,500			37,200		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Lead (Pb)	693SB001	47.4	400	98.3	3.2	400	NA
	694SB001	5.3			NT		
	693SB002	36.3			NT		
	694SB002	48.9			NT		
	693SB003	39.3			NT		
	694SB003	49.6			NT		
	693SB004	33			NT		
	694SB004	65.3			NT		
	694SB005	46			NT		
	694SB006	34.7			NT		
	694SB007	72.4			11.2		
	694SB008	53.1			87.4		
	694SB009	**481**			106		
	694SB010	18.2			NT		
	694SB011	98.6			47.1		
	694SB012	105			43.2		
	694SB013	30.7			NT		
	694SB014	391			NT		
	694SB015	51.6			47.5		
	694SB016	81.3			57		
	694SB017	50.9			23.3		
	694SB018	133			NT		
	694SB019	177			NT		
	694SB024	35.6			90.8		
	694SB025	28.9			NT		
	694SB026	31.4			63.6		
	694SB027	27.6			32.8		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Magnesium (Mg)	693SB001	4,955	NL	NA	5,700	NL	NA
	694SB001	355			NT		
	693SB002	5,290			NT		
	694SB002	3,610			NT		
	693SB003	5,560			NT		
	694SB003	5,170			NT		
	693SB004	2,480			NT		
	694SB004	5,550			NT		
	694SB005	5,570			NT		
	694SB006	1,180			NT		
	694SB007	2,940			6,170		
	694SB008	5,290			7,650		
	694SB009	3,080			4,630		
	694SB010	4,790			NT		
	694SB011	3,830			4,570		
	694SB012	3,060			3,870		
	694SB013	3,440			NT		
	694SB014	2,370			NT		
	694SB015	3,160			2,450		
	694SB016	3,040			3,050		
	694SB017	2,750			1,390		
	694SB018	2,350			NT		
	694SB019	1,720			NT		
	694SB024	5,810			1,940		
	694SB025	3,850			NT		
	694SB026	4,310			6,090		
	694SB027	6,700			9,180		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Manganese (Mn)	693SB001	536.5	160	1210	283	480	NA
	694SB001	125			NT		
	693SB002	536			NT		
	694SB002	439			NT		
	693SB003	415			NT		
	694SB003	587			NT		
	693SB004	315			NT		
	694SB004	476			NT		
	694SB005	703			NT		
	694SB006	83.5			NT		
	694SB007	322			93.1		
	694SB008	573			567		
	694SB009	426			90.6		
	694SB010	140			NT		
	694SB011	333			246		
	694SB012	156			271		
	694SB013	240			NT		
	694SB014	403			273		
	694SB015	230			194		
	694SB016	251			115		
	694SB017	350			NT		
	694SB018	194			NT		
	694SB019	295			NT		
	694SB024	738			170		
	694SB025	390			NT		
	694SB026	447			293		
	694SB027	582			747		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Mercury (Hg)	693SB001	0.195	2.3	0.63	ND	1	NA
	693SB002	0.21			NT		
	694SB002	0.27			NT		
	693SB003	0.24			NT		
	694SB003	0.19			NT		
	693SB004	0.25			NT		
	694SB004	0.37			NT		
	694SB005	0.29			NT		
	694SB006	0.13			NT		
	694SB007	0.44			0.07		
	694SB008	0.49			**1.4**		
	694SB009	0.57			0.53		
	694SB011	0.46			0.35		
	694SB012	0.29			0.28		
	694SB013	0.26			NT		
	694SB014	0.96			NT		
	694SB015	0.27			0.19		
	694SB016	0.27			0.25		
	694SB017	0.27			0.09		
	694SB018	0.27			NT		
	694SB019	1.7			NT		
	694SB024	0.23			0.09		
	694SB025	0.12			NT		
	694SB026	0.11			0.34		
	694SB027	0.25			0.14		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Nickel (Ni)	693SB001	17.35	160	24.5	11.7	65	NA
	694SB001	1.7			NT		
	693SB002	19.3			NT		
	694SB002	17.7			NT		
	693SB003	22			NT		
	694SB003	19.7			NT		
	693SB004	8.5			NT		
	694SB004	18.2			NT		
	694SB005	24.4			NT		
	694SB006	9.7			NT		
	694SB007	13.2			19.4		
	694SB008	21.5			22.5		
	694SB009	37.1			18.1		
	694SB010	9.3			NT		
	694SB011	15.3			18.9		
	694SB012	19.2			16.7		
	694SB013	10.1			NT		
	694SB014	35.8			NT		
	694SB015	12.6			9.5		
	694SB016	13.1			20.2		
	694SB017	10.5			4.7		
	694SB018	12.4			NT		
	694SB019	20.2			NT		
	694SB024	24.1			15		
	694SB025	11.7			NT		
	694SB026	12.8			21		
	694SB027	16.4			20		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Potassium (K)	693SB001	2,555	NL	NA	1,370	NL	NA
	694SB001	172			NT		
	693SB002	2,990			NT		
	694SB002	2,000			NT		
	693SB003	3,080			NT		
	694SB003	2,750			NT		
	693SB004	1,100			NT		
	694SB004	2,690			NT		
	694SB005	3,340			NT		
	694SB006	477			NT		
	694SB007	1,280			1,590		
	694SB008	3,180			2,370		
	694SB009	1,220			1,380		
	694SB010	5,800			NT		
	694SB011	1,700			1,360		
	694SB012	990			1,310		
	694SB013	3,030			NT		
	694SB014	759			NT		
	694SB015	1,270			894		
	694SB016	1,460			1,140		
	694SB017	1,470			514		
	694SB018	1,010			NT		
	694SB019	634			NT		
	694SB024	2,140			935		
	694SB025	1,690			NT		
	694SB026	1,900			2,680		
	694SB027	2,790			4,090		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Selenium (Se)	694SB005	4.7	39	1.24	NT	2.6	NA
	694SB010	2.2			NT		
	694SB012	0.85			1.3		
	694SB014	1.5			NT		
	694SB015	0.69			0.82		
	694SB017	0.96			ND		
	694SB018	0.95			NT		
	694SB019	1.2			NT		
	694SB024	1.2			ND		
Silver (Ag)	693SB001	0.72	39	0.41	ND	17	NA
	694SB001	0.31			NT		
	693SB002	0.66			NT		
	694SB002	0.74			NT		
	693SB003	0.73			NT		
	694SB003	0.51			NT		
	693SB004	0.5			NT		
	694SB004	0.47			NT		
	694SB005	1.2			NT		
	694SB007	0.41			ND		
	694SB009	0.43			ND		
	694SB014	0.44			NT		
	694SB015	ND			0.33		
	694SB016	0.32			NT		
	694SB018	0.61			NT		
	694SB019	1.2			NT		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Sodium (Na)	693SB001	322.5	NL	NA	2,210	NL	NA
	694SB001	546			NT		
	693SB002	1,350			NT		
	694SB002	784			NT		
	693SB003	1,290			NT		
	694SB003	1,610			NT		
	693SB004	167			NT		
	694SB004	3,160			NT		
	694SB005	337			NT		
	694SB006	475			NT		
	694SB007	414			2,250		
	694SB008	566			2,010		
	694SB009	423			2,040		
	694SB010	4,440			NT		
	694SB011	477			1,450		
	694SB012	614			655		
	694SB013	384			NT		
	694SB014	803			NT		
	694SB015	2,080			1,800		
	694SB016	471			816		
	694SB017	317			218		
	694SB018	1,190			NT		
	694SB019	762			NT		
	694SB024	951			2,650		
	694SB025	719			NT		
	694SB026	774			4,470		
	694SB027	5,130			12,200		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Tin (Sn)	693SB001	16	4,700	39.1	ND	5,500	NA
	694SB003	22.4			NT		
	694SB004	18.6			NT		
	694SB008	29.3			18.7		
	694SB009	31.3			ND		
	694SB012	ND			73.3		
	694SB014	284			NT		
	694SB015	36			ND		
	694SB017	210			ND		
	694SB018	33			NT		
	694SB019	40.9			NT		
	694SB024	7.4			26.8		
	694SB025	5.9			NT		
	694SB026	6.1			7.5		
	694SB027	9.3			11.9		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Vanadium (V)	693SB001	68.5	55	75.9	23.4	3,000	NA
	694SB001	4.3			NT		
	693SB002	**87.8**			NT		
	694SB002	51			NT		
	693SB003	**86.3**			NT		
	694SB003	70.7			NT		
	693SB004	39.3			NT		
	694SB004	55.8			NT		
	694SB005	**92.2**			NT		
	694SB006	11.8			NT		
	694SB007	41.2			29.5		
	694SB008	66.1			55.2		
	694SB009	57			25.9		
	694SB010	54.6			NT		
	694SB011	41.9			30.3		
	694SB012	20.5			33.3		
	694SB013	48			NT		
	694SB014	23.7			NT		
	694SB015	29.6			21.9		
	694SB016	33.9			26.5		
	694SB017	33.2			17.6		
	694SB018	26.5			NT		
	694SB019	26.1			NT		
	694SB024	61.4			20.8		
	694SB025	42.7			NT		
	694SB026	44.1			67.9		
	694SB027	65.2			81.4		

Table 10.6.4
AOCs 693 and 694
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Zinc (Zn)	693SB001	159	2,300	236	63.1	6,200	NA
	693SB002	139			NT		
	694SB002	122			NT		
	693SB003	139			NT		
	694SB003	165			NT		
	693SB004	105			NT		
	694SB004	204			NT		
	694SB005	139			NT		
	694SB006	101			NT		
	694SB007	224			57.7		
	694SB008	157			341		
	694SB009	792			213		
	694SB010	38.9			NT		
	694SB011	169			243		
	694SB012	350			105		
	694SB013	67.9			NT		
	694SB014	702			NT		
	694SB015	128			151		
	694SB016	218			250		
	694SB017	103			48.6		
	694SB018	270			NT		
	694SB019	602			NT		
	694SB024	113			341		
	694SB025	81.9			NT		
	694SB026	84.7			164		
	694SB027	93.1			141		

Notes:

*	=	Residential RBCs (THQ=0.1) were used as a reference concentration for upper-interval samples. Generic soil-to groundwater SSLs (DAF=10) from *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as a reference concentration for lower-interval samples

Bold concentrations exceed the RBCs, SSL, and the zone background
All background values for Zone K are based on twice the means of the grid sample concentrations.

DAF	=	Dilution attenuation factor
NA	=	Not applicable/not available/not analyzed
ND	=	Not detected/not determined
NT	=	Not taken
RBC	=	Risk-based concentration
SSL	=	Soil screening level
THQ	=	Target hazard quotient
μg/kg	=	Micrograms per kilogram
ng/kg	=	Nanograms per kilogram
mg/kg	=	Milligrams per kilogram
NA	=	Not Applicable/Not Available
**	=	Number of nondetects prevented determination of background concentration

Volatile Organic Compounds in Soil

Three VOCs (acetone, 2-butanone, and carbon disulfide) were detected in the soil samples collected in the AOCs 693 and 694 area. Acetone and carbon disulfide were each detected in only one upper-interval sample. 2-butanone was detected in only one lower-interval sample. Each detection was between 2 and 7 μg/kg, which was lower than the VOCs respective upper- and lower-interval RBC/SSL screening levels by three to five orders of magnitude.

Semivolatile Organic Compounds in Soil

Thirteen SVOCs were detected in soil samples collected from the AOCs 693 and 694 area; 10 were detected in both surface and subsurface samples. Of the SVOCs detected, only benzo(a)pyrene exceeded its RBC. All five benzo(a)pyrene surface soil interval detections (694SB00301, 00901, 01301, 01601, and 01801) exceeded its 87 μg/kg RBC. The BEQ calculated for these samples also exceeded the 87 μg/kg B(a)P RBC. However, all detected B(a)P concentrations were within one order of magnitude of the RBC. Figure 10.6.2 shows BEQ values calculated for surface soil sample locations.

No lower-interval SVOC concentration exceeded its respective SSL.

Pesticides/PCBs in Soil

Ten pesticide compounds were detected in the soil samples collected at AOCs 693 and 694. Seven were in both upper- and lower-interval soil samples. No upper-interval pesticide detection exceeded a respective RBC. Only one subsurface detection, a dieldrin concentration, (4.82 μg/kg at 694SB011) exceeded its 1.81 μg/kg SSL. The exceedance was the same order of magnitude as the SSL.

Aroclor-1260 was detected in 14 of 23 upper-interval soil samples and six of nine lower-interval samples. Only one surface detection (596 μg/kg at 694SB01401) exceeded Aroclor-1260's

320 μg/kg RBC screening concentration. This detection was within the same order of magnitude as the screening concentration. All subsurface concentrations were below the applicable SSL.

Other Organic Compounds in Soil

Dioxins were detected in all of the samples collected at AOCs 693 and 694. All dioxin concentrations detected in site samples were below their respective RBC/SSL screening concentrations. However, the calculated TEQs for three surface samples (7.31 ng/kg, 8.61 ng/kg and 9.45 ng/kg for borings 694SB02401, 02501, and 02601, respectively) exceeded the 2,3,7,8-TCDD RBC of 4.3 ng/kg.

Inorganics in Soil

Twenty-three inorganics were detected in soil at AOCs 693 and 694. The following inorganics exceeded either an applicable RBC or SSL, and if available, the applicable background concentration: aluminum, antimony, arsenic, copper, iron, lead, manganese, mercury, and vanadium.

Aluminum was detected at most sampling locations. Five surface interval concentrations (at locations 693SB002 and 003, and 694SB003, 005, and 008) exceeded the RBC and surface background. However, all aluminum exceedances were of the same order of magnitude as the RBC. All subsurface detections were below the applicable SSL. Figure 10.6.3 shows aluminum concentrations detected in surface soil.

Five surface interval antimony concentrations (at locations 694SB005, 009, 012, 014, and 019) exceeded the RBC and one subsurface concentration (4.7 mg/kg at location 694SB026) exceeded the SSL. However, all antimony RBC and SSL exceedances were with the same order of magnitude as the screening concentrations, with the exception of the 27.9 mg/kg surface interval detection at 694SB01201. Figure 10.6.4 shows antimony concentrations detected in surface soil.

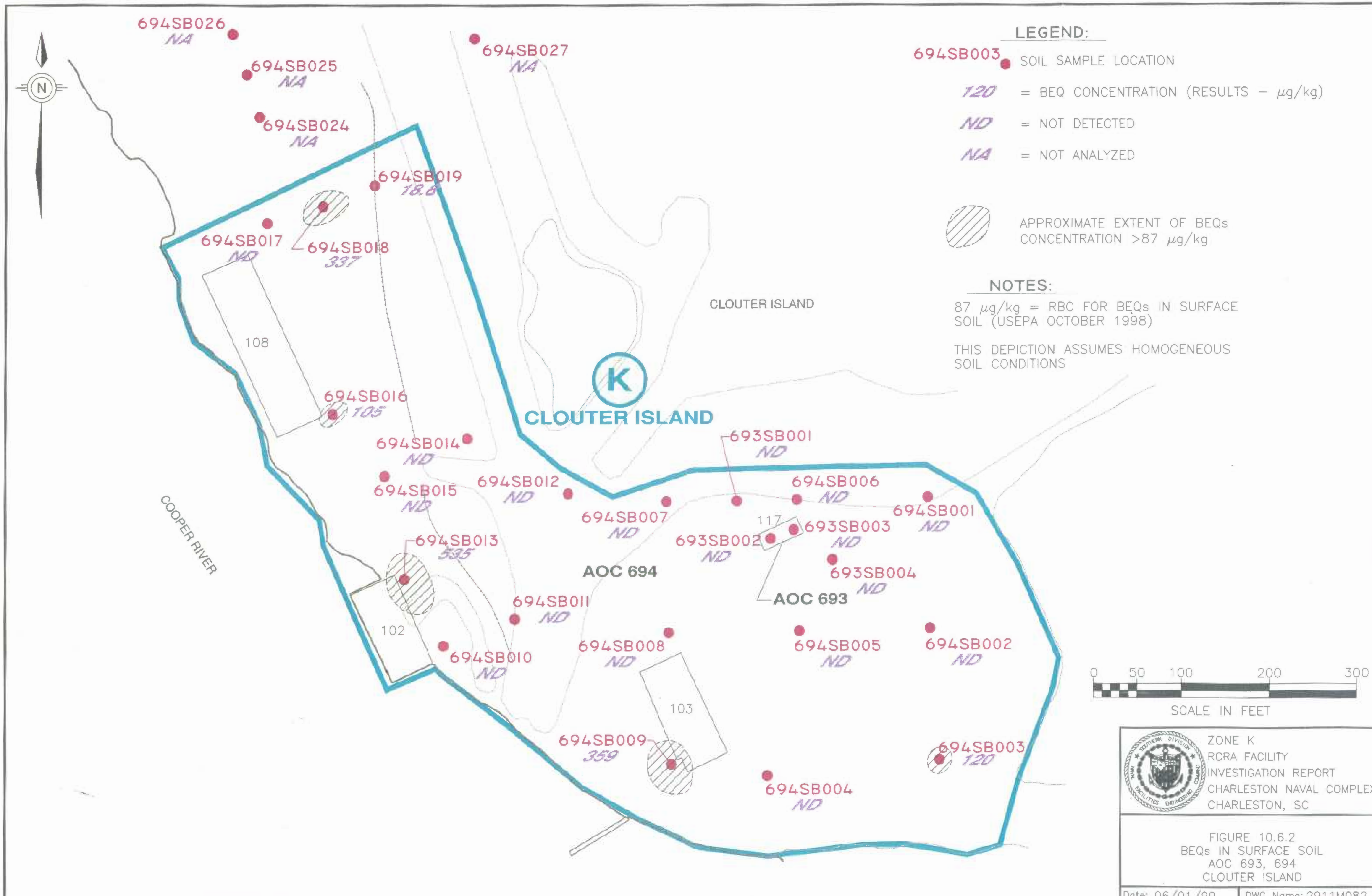
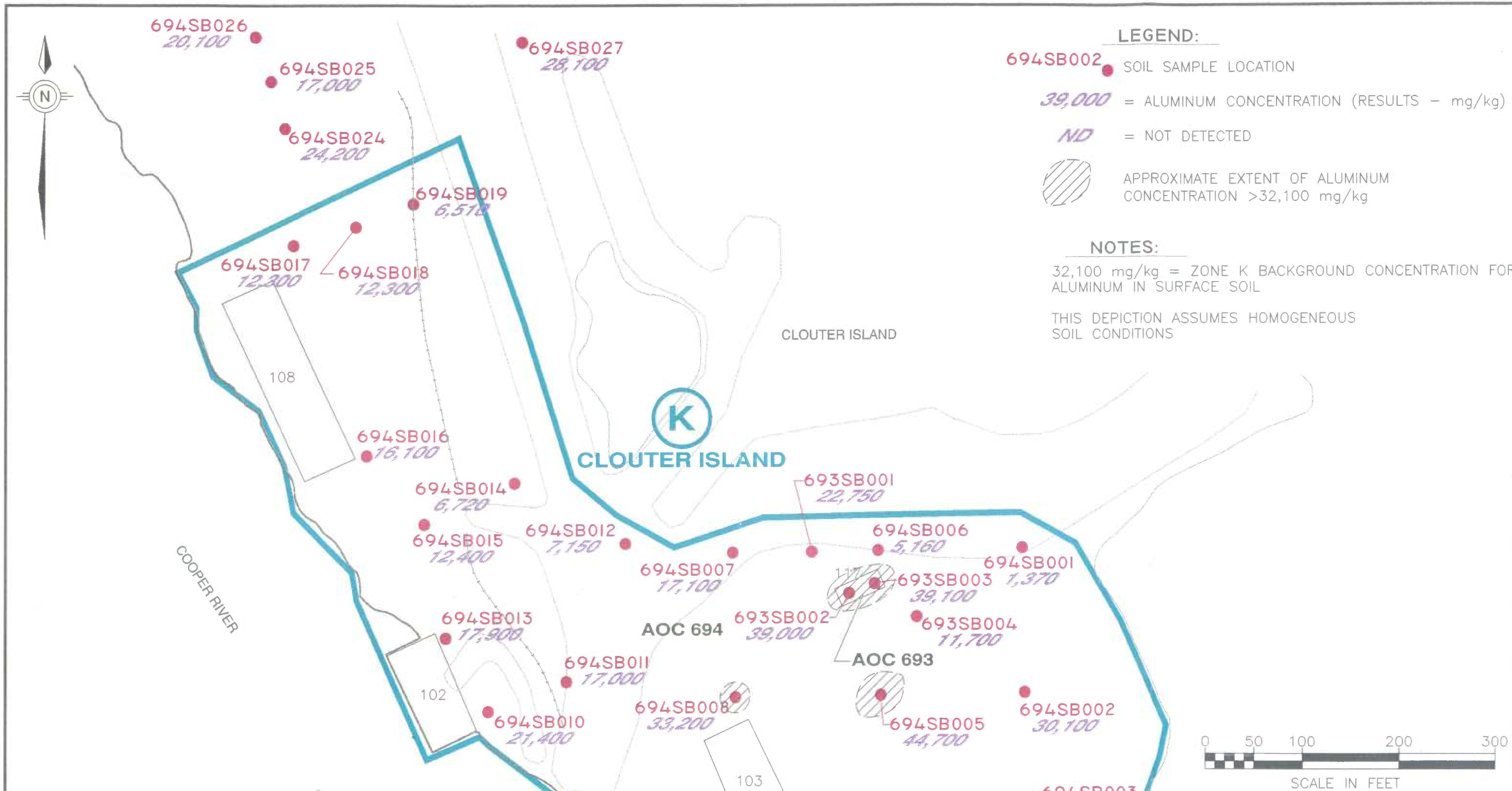


FIGURE 10.6.2
BEQs IN SURFACE SOIL
AOC 693, 694
CLOUTER ISLAND

00149 T B122



ZONE K
RCRA FACILITY
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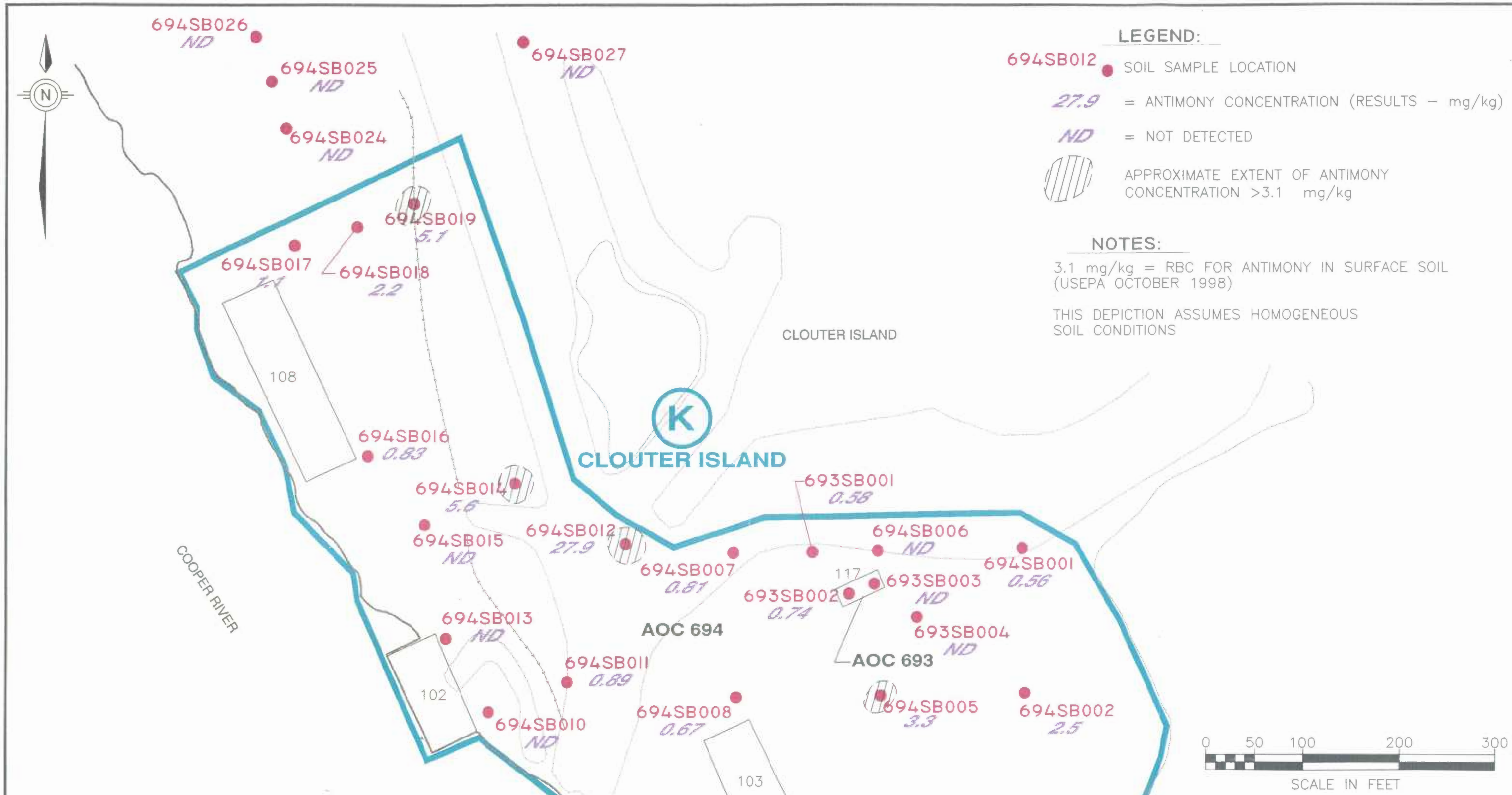
CHARLESTON, SC

FIGURE 10.6.3
ALUMINUM IN SURFACE SOIL
AOC 693, 694
CLOUTER ISLAND

Date: 06/01/99 | DWG Name: 2911M083



ZONE K
RCRA FACILITY
INVESTIGATION REPORT
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CHARLESTON, SC

FIGURE 10.6.4
ANTIMONY IN SURFACE SOIL
AOC 693, 694
CLOUTER ISLAND

Date: 06/01/99 | DWG Name: 2911M084

Arsenic was detected at most sampling locations. Only one surface interval arsenic concentration (25.8 mg/kg at location 694SB005) exceeded the RBC and surface background. Arsenic was less frequently detected in the lower-interval; only two lower-interval samples (at locations 694SB008 and 027) exceeded the SSL and subsurface background. Figure 10.6.5 shows arsenic concentrations detected in subsurface soil.

Chromium was detected at most sampling locations. No evidence of hexavalent chromium has been detected at Clouter Island; therefore, the trivalent chromium RBC/SSL screening concentrations have been used. All surface or subsurface soil concentrations at AOCs 693 and 694 were below the respective trivalent chromium RBC and SSL.

Copper was detected at most sampling locations. Only one copper detection, a single upper-interval concentration (1020 mg/kg at location 694SB014), exceeded the RBC and background concentration. The single exceedance is anomalously high relative to the other copper detections in both intervals.

Iron was detected at most sampling locations. Three surface-interval iron concentrations (at locations 693SB002 and 003, and 694SB005) exceeded the RBC and background concentration. Iron was also commonly detected in the lower-interval, but no SSL is listed for iron. Figure 10.6.6 shows iron concentrations detected in surface soil.

Lead was detected at most sampling locations. Only one surface interval concentration (481 mg/kg at location 694SB009) exceeded the RBC. This single exceedance was within the same order of magnitude as the RBC. The highest lower-interval lead detection also occurred at this location; however, none of the lower-interval detections exceeded the SSL.

Manganese was detected at most sampling locations. Most surface interval concentrations detected exceeded the RBC; however, all were below the 1,210 mg/kg surface background concentration. Manganese was infrequently detected in the lower-interval, of which only one concentration (747 mg/kg at 694SB027) exceeded the SSL.

Mercury was detected at most sampling locations. All surface interval detections were below the applicable RBC and background. Mercury was infrequently detected in the lower-interval, of which only one concentration (1.4 mg/kg at location 694SB008) slightly exceeded the SSL. No subsurface background concentration is available.

Vanadium was detected at most sampling locations. Three surface detections (at locations 694SB002, 003, and 005) exceeded both the RBC and surface background concentration. However, all upper-interval exceedances were within the same order of magnitude as the RBC. Vanadium was infrequently detected in the lower-interval. All lower-interval samples were below the SSL. Figure 10.6.7 show vanadium concentrations detected in surface soil.

10.6.3 Groundwater Sampling and Analysis

The final RFI work plan proposed the installation of seven shallow temporary monitoring wells for the AOCs 693 and 694 area of Clouter Island. The wells were installed using a hand auger to a depth a few feet below the water table. Standard well construction materials were used to complete the wells including 2-inch diameter PVC screen, filter pack, and bentonite pellets. No surface pads were constructed; however, the tops of the wells were locked.

Six of the temporary monitoring wells are in the area identified as AOCs 693 and 694 and the Cooper River. The seventh well is upgradient of the AOCs 693 and 694 area, and is not considered a site well. This well, NBCKGDKCLI, is the background well for Clouter Island. All well locations are shown on Figure 10.6.1.

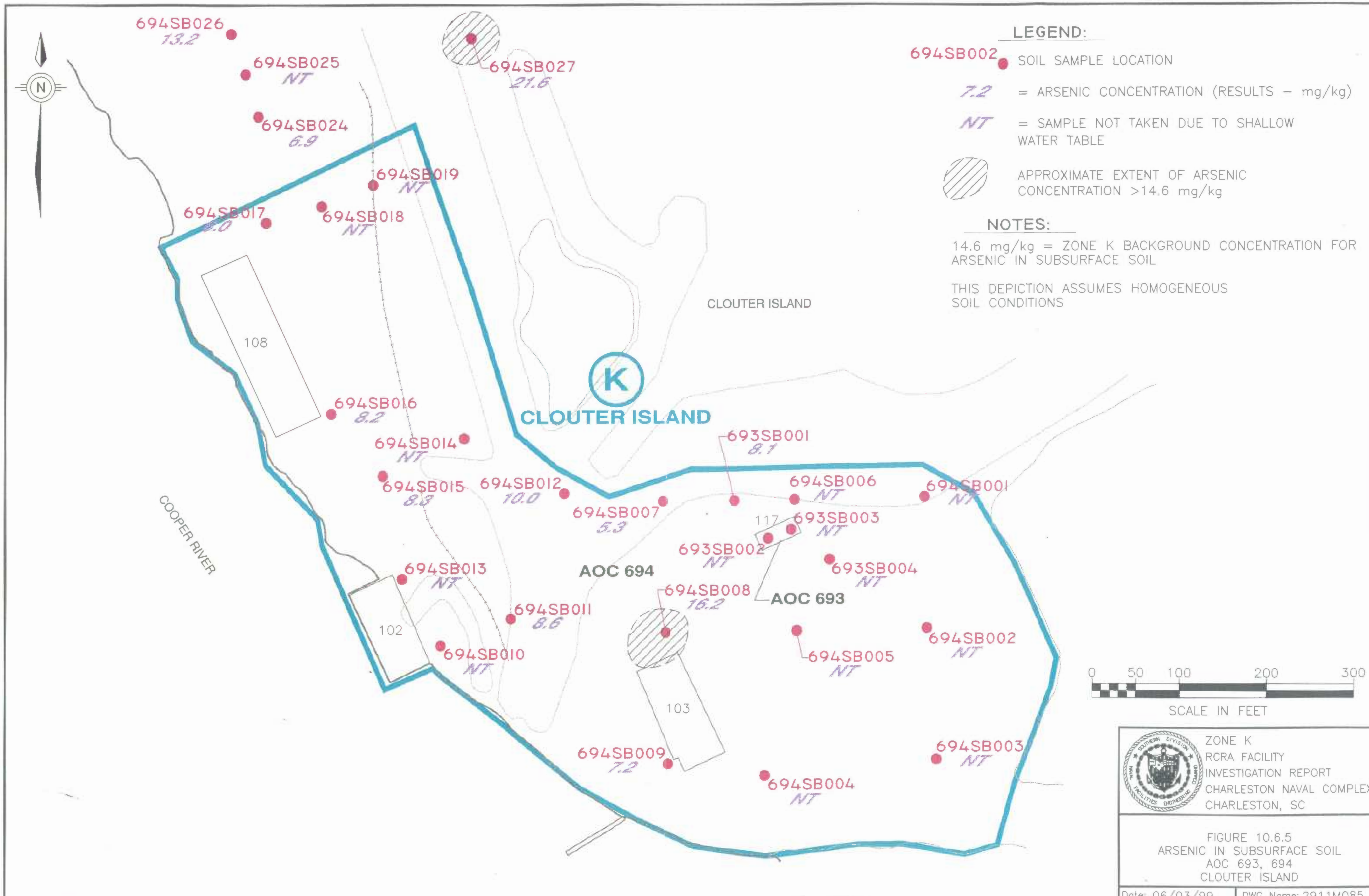
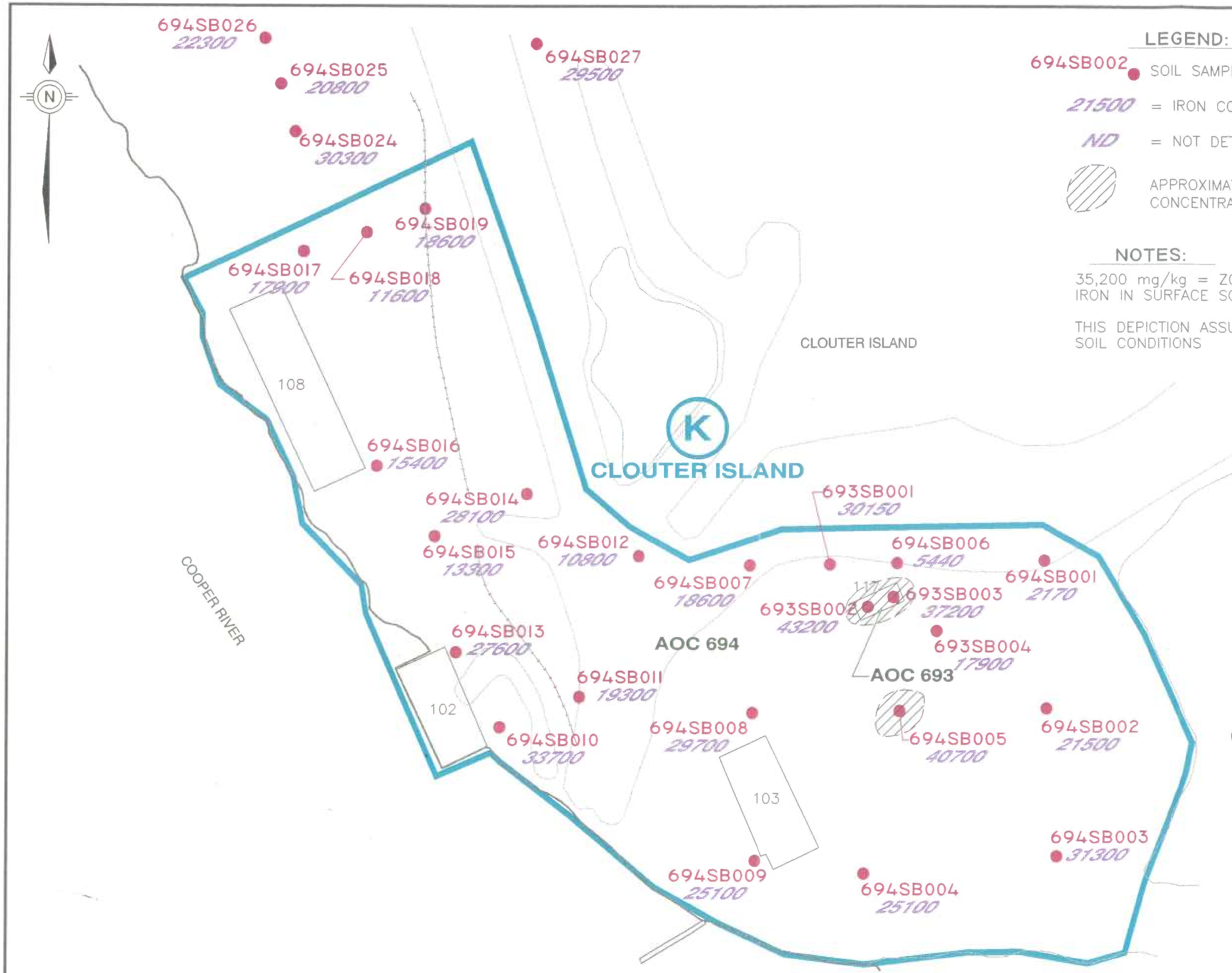


FIGURE 10.6.5
ARSENIC IN SUBSURFACE SOIL
AOC 693, 694
CLOUTER ISLAND

00149 TB132



LEGEND:

694SB002 ● SOIL SAMPLE LOCATION

21500 = IRON CONCENTRATION (RESULTS – mg/kg)

ND = NOT DETECTED

APPROXIMATE EXTENT OF IRON CONCENTRATION >35,200 mg/kg

NOTES:

35,200 mg/kg = ZONE K BACKGROUND CONCENTRATION FOR IRON IN SURFACE SOIL

THIS DEPICTION ASSUMES HOMOGENEOUS SOIL CONDITIONS

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FIGURE 10.6.6
IRON IN SURFACE SOIL
AOC 693, 694
CLOUTER ISLAND

Date: 06/02/99 | DWG Name: 2911M086

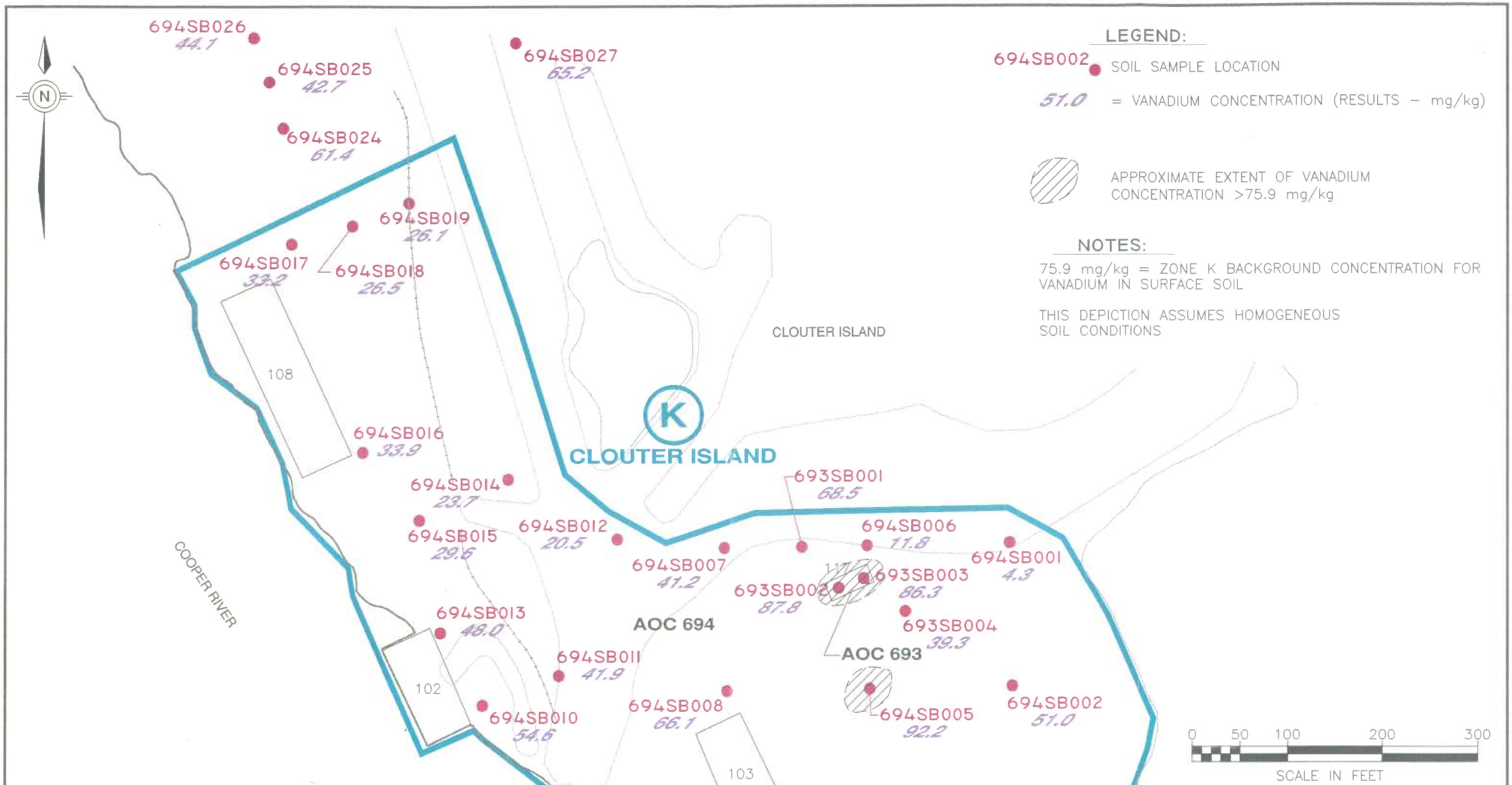

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FIGURE 10.6.7
VANADIUM IN SURFACE SOIL
AOC 693, 694
CLOUTER ISLAND

Date: 05/28/99 | DWG Name: 2911M087

After installation and development of the seven temporary wells proposed in the final RFI work plan, the first-round RFI samples were collected in May 1997 and analyzed for Appendix IX analytical parameters at DQO Level III.

Second-round through fourth-round analytical parameters for the AOC 694 temporary wells were based on first-round detections. Second through fourth round samples were collected in July 1997, December 1997/January 1998, and March 1998, and analyzed at DQO Level III for metals, cyanide, VOCs, SVOCs, and dioxins. Based on dioxins and metals results from the previous rounds of sampling, additional samples for dioxins, metals and TSS analyses were collected in January 1999 (round 5) to determine the potential impacts of suspended sediment on analytical results Table 10.6.5 summarizes groundwater sampling at AOCs 693 and 694.

The temporary monitoring wells were installed to within a few feet below the water table. In most wells, this depth was approximately 5 to 6 feet bgs. One well, installed in the area of a pile of granular material of unknown origin, was approximately 8 feet deep.

10.6.4 Nature and Extent of Contamination in Groundwater

Table 10.6.6 summarizes organic groundwater analytical results and Table 10.6.7 summarizes groundwater inorganic analytical results for AOCs 693 and 694. Table 10.6.8 summarizes all analytes detected in shallow groundwater at AOCs 693 and 694. Analyte concentrations are listed in bold if they exceeded their respective screening concentrations, the lower of the applicable tap-water RBC or MCL and, when available, the associated shallow groundwater background concentration. Appendix F is a complete analytical data report for all samples collected in Zone K, including those collected at AOCs 693 and 694.

Table 10.6.5
AOCs 693 and 694
Groundwater Sampling Summary

Sampling Round	Sampling Date	Wells Sampled	Sample Analyses	Comments
1	5/14-16/97	694002 694003 694004 694005 694006 694007[a]	Appendix IX	694001(NBCKGDKCL1) was sampled but is considered the background well for Clouter Island.
2	7/17-21/97	694002 694003 694004 694005 694006 694007[a]	VOCs, SVOCs, metals, cyanide, and dioxin	None
3	12/17/97- 1/12/98	694002 694003 694004 694005 694006 694007[a]	VOCs, SVOCs, metals, cyanide, and dioxin	None
4	3/16-19/98	694002 694003 694004 694005 694006 694007[a]	VOCs, SVOCs, metals, cyanide, and dioxin	None
5	1/11-13/99	694005 694006 694007	Dioxin and metals TSS	Samples collected to determine impacts of suspended sediment.

Note:
[a] = One duplicate sample was also collected and analyzed for the same parameters.

Table 10.6.6
AOCs 693 and 694
Organics Detected In Groundwater

Parameter	Sample Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/MCL	Number of Samples Exceeding RBC or MCL
Volatile Organic Compounds (μg/L)						
4-Methyl-2-Pentanone (MIBK)	First	0/6	ND	ND	290/NL	0
	Second	0/6	ND	ND		NA
	Third	1/6	10	10		NA
	Fourth	0/6	ND	ND		NA
Acetone	First	0/6	ND	ND	370/NL	NA
	Second	0/6	ND	ND		NA
	Third	1/5	3	3		0
	Fourth	0/2	ND	ND		NA

Table 10.6.6
AOCs 693 and 694
Organics Detected In Groundwater

Parameter	Sample Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/MCL	Number of Samples Exceeding RBC or MCL
Carbon disulfide	First	0/6	ND	ND	100/NL	NA
	Second	0/6	ND	ND		NA
	Third	1/6	2	2		0
	Fourth	0/6	ND	ND		NA
Trichloroethene	First	0/6	ND	ND	1.6/5	NA
	Second	0/6	ND	ND		NA
	Third	0/6	ND	ND		NA
	Fourth	1/6	2	2		1
Semivolatile Organic Compounds ($\mu g/L$)						
Benzoic acid	First	0/6	ND	ND	15,000/NL	NA
	Second	0/6	ND	ND		NA
	Third	1/6	6	6		0
	Fourth	0/6	ND	ND		NA
Naphthalene	First	0/5	ND	ND	73/NL	NA
	Second	0/6	ND	ND		NA
	Third	0/6	ND	ND		NA
	Fourth	1/6	7	7		0
Dioxins (pg/L) (6 samples collected during both sampling rounds)						
TCDD TEQ	First	6/6	0.0074 - 0.11	0.0031	0.45/30	0
	Second	6/6	0.012 - 0.17	0.07		NA
	Third	6/6	0.0026 - 0.06	0.026		NA
	Fourth	6/6	0.004 - 0.23	0.061		NA
1234678-HpCDD	First	1/6	5.42	5.42	45/NL	0
	Second	2/6	3.74 - 8.7	6.22		0
	Third	1/6	3.06	3.06		0
	Fourth	0/6	ND	ND		NA
1234678-HpCDF	First	1/6	4.44	4.44	45/NL	0
	Second	2/6	1.28 - 2.61	1.95		0
	Third	0/6	ND	ND		NA
	Fourth	0/6	ND	ND		NA
OCDD	First	5/6	7.36 - 51.8	17.03	450/NL	0
	Second	6/6	12.4 - 82.1	40.6		0
	Third	6/6	2.62 - 58.1	20.5		0
	Fourth	5/6	4.05 - 82.1	20.16		0
OCDF	First	0/6	ND	ND	450/NL	NA
	Second	2/6	4.46 - 10.1	7.28		0
	Third	0/6	ND	ND		NA
	Fourth	0/6	ND	ND		NA

Notes:
NA = Not applicable/not available/not analyzed
ND = Not detected/not determine
NL = Not listed

Table 10.6.7
AOCs 693 and 694
Inorganics Detected Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and Background
Inorganics (6 shallow groundwater samples collected during four events)							
Aluminum	First (Jan. 97)	0/6			3,700/50	NA	0
	Second (April 97)	2/6	262 - 307	285			0
	Third ((July 97)	0/6					NA
	Fourth (Oct. 97)	0/6					NA
Arsenic	First (Dec. 95)	3/6	3.4 - 66.9	37.8	0.045/50	15.1	2
	Second (April 97)	4/6	3 - 63.3	29.6			2
	Third ((July 97)	2/6	38.9 - 57.7	48.3			2
	Fourth (Oct. 97)	4/6	2.4 - 51.2	25.9			2
Barium	First (Dec. 95)	6/6	17.4 - 71	41.7	260/2,000	95.9	0
	Second (April 97)	6/6	30.3 - 71	45.1			0
	Third ((July 97)	5/6	28 - 61.4	45.3			0
	Fourth (Oct. 97)	6/6	19.8 - 61.1	35.7			0
Beryllium	First (Dec. 95)	0/6			7.3/4	NA	NA
	Second (April 97)	1/6	4.9	4.9			1
	Third ((July 97)	2/6	0.23 - 0.4	0.32			0
	Fourth (Oct. 97)	0/6					NA
Cadmium	First (Dec. 95)	2/6	2.1 - 5.9	4	1.8/5	0.40	2
	Second (April 97)	3/6	0.4 - 19.3	6.8			1
	Third ((July 97)	1/6	0.6	0.6			0
	Fourth (Oct. 97)	0/6					NA
Calcium	First (Dec. 95)	6/6	198,000 - 320,000	247,500	NL/NL	NA	NA
	Second (April 97)	6/6	196,000 - 355,000	271,333			NA
	Third ((July 97)	6/6	186,500 - 371,000	244,250			NA
	Fourth (Oct. 97)	6/6	143,000 - 445,000	249,917			NA
Chromium	First (Dec. 95)	3/6	1.6 - 3	2.5	11/100	NA	0
	Second (April 97)	3/6	15.7 - 42.3	28.8			3
	Third ((July 97)	0/6					NA
	Fourth (Oct. 97)	2/6	1.7 - 1.7	1.7			0
Cobalt	First (Dec. 95)	0/6			220/NL	NA	NA
	Second (April 97)	1/6	18.9	18.9			0
	Third ((July 97)	1/6	3.2	3.2			0
	Fourth (Oct. 97)	1/6	2.5	2.5			0
Copper	First (Dec. 95)	1/6	24.9	24.9	150/1,000	5.78	0
	Second (April 97)	3/6	24.6 - 54.7	34.7			0
	Third ((July 97)	0/6					NA
	Fourth (Oct. 97)	1/6	12	12			0
Cyanide	First (Dec. 95)	1/6	2	2	73/200	NA	0
	Second (April 97)	0/6					NA
	Third ((July 97)	0/6					NA
	Fourth (Oct. 97)	0/6					NA

Table 10.6.7
AOCs 693 and 694
Inorganics Detected Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and Background
Iron	First (Dec. 95)	6/6	722 - 24,800	7,610	NL/NL	9170	2
	Second (April 97)	6/6	266 - 25,200	8,163			2
	Third ((July 97)	5/6	2,070 - 20,100	7,383			1
	Fourth (Oct. 97)	5/6	1,470 - 19,800	7,592			2
Lead	First (Dec. 95)	1/6	2.7	2.7	NL/15	NA	0
	Second (April 97)	1/6	2.7	2.7			0
	Third ((July 97)	0/6					NA
	Fourth (Oct. 97)	2/6	0.98 - 1.2	1.09			0
Magnesium	First (Dec. 95)	6/6	69,300 - 402,000	242,633	NL/NL	NA	NA
	Second (April 97)	6/6	111,000 - 357,000	224,250			NA
	Third ((July 97)	6/6	71,700 - 337,000	195,950			NA
	Fourth (Oct. 97)	6/6	71,000 - 277,500	171,917			NA
Manganese	First (Dec. 95)	6/6	75.9 - 2,600	1,240	73/50	1210	4
	Second (April 97)	6/6	270 - 2,670	1,355			4
	Third ((July 97)	6/6	307 - 2,020	1,195			4
	Fourth (Oct. 97)	6/6	218 - 1,830	1,105			2
Mercury	First (Dec. 95)	0/6	ND	ND	1.1/2	NA	NA
	Second (April 97)	2/6	1.1 - 1.6	1.35			1
	Third ((July 97)	0/6	ND	ND			NA
	Fourth (Oct. 97)	1/6	7.6	7.6			1
Nickel	First (Dec. 95)	1/6	2.8	2.8	73/100	2.84	0
	Second (April 97)	2/6	9.2 - 19.3	14.25			0
	Third ((July 97)	4/6	0.73 - 6.3	3.2			0
	Fourth (Oct. 97)	1/6	8.3	8.3			0
Potassium	First (Dec. 95)	6/6	39,300 - 122,000	83,650	NL/NL	NA	NA
	Second (April 97)	6/6	49,500 - 919,500	216,867			NA
	Third ((July 97)	6/6	21,900 - 107,000	67,333			NA
	Fourth (Oct. 97)	6/6	21,200 - 86,550	60,658			NA
Selenium	First (Dec. 95)	0/6	ND	ND	18/50	NA	NA
	Second (April 97)	0/6	ND	ND			NA
	Third ((July 97)	1/6	4	4			0
	Fourth (Oct. 97)	0/6	ND	ND			NA
Silver	First (Dec. 95)	0/6	ND	ND	18/100	NA	NA
	Second (April 97)	1/6	35.3	35.3			NA
	Third ((July 97)	0/6	ND	ND			NA
	Fourth (Oct. 97)	0/6	ND	ND			NA
Sodium	First (Dec. 95)	6/6	63,300 - 3,360,000	2,021,383	NL/NL	NA	NA
	Second (April 97)	6/6	66,700 - 3,470,000	2,086,117			NA
	Third ((July 97)	6/6	38,600 - 4,710,000	2,240,600			NA
	Fourth (Oct. 97)	6/6	26,900 - 2,410,000	1,431,983			NA

Table 10.6.7
AOCs 693 and 694
Inorganics Detected Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and Background
Tin	First (Dec. 95)	0/6	ND	ND	2,200/NL	34.6	NA
	Second (April 97)	1/6	367	367			0
	Third ((July 97)	0/6	NA	ND			NA
	Fourth (Oct. 97)	0/6	ND	ND			NA
Vanadium	First (Dec. 95)	6/6	1.135 - 5.5	3.31	26/NL	9.1	0
	Second (April 97)	5/6	1.3 - 6.2	4			0
	Third ((July 97)	5/6	1.2 - 5.2	2.55			0
	Fourth (Oct. 97)	5/6	1.3 - 4.9	2.64			0
Zinc	First (Dec. 95)	0/6	ND	ND	1,100/5,000	NA	NA
	Second (April 97)	0/6	ND	ND			NA
	Third ((July 97)	0/6	ND	ND			NA
	Fourth (Oct. 97)	1/6	33.6	33.6			0

Notes:
Lead does not have an RBC. Therefore, the USEPA Treatment Technique Action Level (TTAL) of 15 μg/L has been substituted for the RBC.
NA = Not applicable/not available/not analyzed
NL = Not listed

Table 10.6.8
AOCs 693 and 694
Analytes Detected in Shallow Groundwater

Parameter	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Tap-water RBC/MCL	Shallow Background
Volatile Organic Compounds (μg/L)							
4-Methyl-2-Pentanone (MIBK)	694006	ND	ND	10	ND	290/NL	NA
Acetone	694007	ND	ND	3	ND	370/NL	NA
Carbon disulfide	694006	ND	ND	2	ND	100/NL	NA
Trichloroethene	694002	ND	ND	ND	2	1.6/5	NA
Semivolatile Organic Compounds (μg/L)							
Benzoic acid	694003	ND	ND	6	ND	15,000/NA	NA
Naphthalene	694007	ND	ND	ND	7	73/NL	NA

Table 10.6.8
AOCs 693 and 694
Analytes Detected in Shallow Groundwater

Parameter	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Tap-water RBC/MCL	Shallow Background
Dioxins (pg/L) **(6 samples collected during both sampling rounds)**							
TCDD TEQ	694002	0.044	0.065	0.032	0.026	0.45/30	NA
	694003	0.009	0.0124	0.058	0.018		
	694004	0.106	0.092	0.002	0.033		
	694005	0.007	0.057	0.0131	0.004		
	694006	0.009	0.169	0.005	ND		
	694007	0.007	0.026	0.043	0.225		
1234678-HpCDD	694002	ND	3.74	ND	ND	45/NL	NA
	694004	5.42	ND	ND	ND		
	694006	ND	8.7	ND	ND		
	694007	ND	ND	3.06	ND		
1234678-HpCDF	694002	4.44	1.28	ND	ND	45/NL	NA
	694006	ND	2.61	ND	ND		
OCDD	694002	ND	14.3	31.8	25.8	450/NL	NA
	694003	8.99	12.4	58.1	17.8		
	694004	51.8	82.1	2.62	33		
	694005	7.52	57	13.1	4.05		
	694006	9.49	51.5	5.17	ND		
	694007	7.36	26.35	12.35	ND		
OCDF	694004	ND	4.46	ND	ND	450/NL	NA
	694006	ND	10.1	ND	ND		
Inorganics **(1 shallow groundwater sample collected during each event)**							
Aluminum	694005	ND	**307**	ND	ND	3,700/50	NA
	694006	ND	**262**	ND	ND		
Arsenic	694002	**66.9**	**63.3**	**57.7**	**51.2**	0.045/50	15.1
	694003	**43.2**	**48.8**	**38.9**	**47.6**		
	694005	ND	3.2	ND	2.4		
	694006	3.4	ND	ND	ND		
	694007	ND	3	ND	2.5		
Barium	694002	71	71	61.4	55.2	260/2,000	95.9
	694003	61.2	55.7	58.5	61.1		
	694004	17.4	30.3	ND	19.8		
	694005	28.2	33.9	31.5	22.9		
	694006	39.3	42.3	37.1	25.1		
	694007	33.25	37.65	28	29.95		
Beryllium	694002	ND	**4.9**	ND	ND	7.3/4	NA
	694005	ND	ND	0.23	ND		
	694006	ND	ND	0.4	ND		
Cadmium	694003	ND	0.56	ND	ND	1.8/5	0.40
	694004	**2.1**	0.4	ND	ND		
	694006	**5.9**	ND	ND	ND		
	694007	ND	**19.3**	0.6	ND		

Table 10.6.8
AOCs 693 and 694
Analytes Detected in Shallow Groundwater

Parameter	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Tap-water RBC/MCL	Shallow Background
Calcium	694002	320,000	342,000	284,000	267,000	NL/NL	NA
	694003	223,000	196,000	193,000	218,000		
	694004	198,000	355,000	371,000	445,000		
	694005	207,000	199,000	189,000	143,000		
	694006	281,000	273,000	242,000	188,000		
	694007	256,000	263,000	186,500	238,500		
Chromium	694002	2.9	**42.3**	ND	1.7	11/100	NA
	694003	1.6	ND	ND	1.7		
	694004	3	ND	ND	ND		
	694006	ND	**28.3**	ND	ND		
	694007	ND	**15.7**	ND	ND		
Cobalt	694002	ND	18.9	ND	ND	220/NL	NA
	694004	ND	ND	3.2	2.5		
Copper	694002	ND	24.8	ND	ND	150/1,000	5.78
	694004	24.9	24.6	ND	12		
	694006	ND	54.7	ND	ND		
Cyanide	694005	2	ND	ND	ND	73/200	
Iron	694002	**24,800**	**25,200**	**20,100**	**19,800**	NL/NL	9170
	694003	**11,100**	**10,400**	8,160	**11,200**		
	694004	722	266	ND	ND		
	694005	1,720	2,840	2,070	1,470		
	694006	3,180	5,240	3,360	1,990		
	694007	4,140	5,030	3,225	3,500		
Lead	694002	ND	ND	ND	0.98	NL/15	NA
	694004	2.7	ND	ND	ND		
	694005	ND	2.7	ND	ND		
	694007	ND	ND	ND	1.2		
Magnesium	694002	182,000	171,000	139,000	119,000	NL/NL	NA
	694003	223,000	182,000	183,000	193,000		
	694004	69,300	111,000	71,700	71,000		
	694005	222,000	198,000	200,000	138,000		
	694006	402,000	357,000	337,000	233,000		
	694007	357,500	326,500	245,000	277,500		
Manganese	694002	**2,600**	**2,670**	**2,020**	**1,830**	73/50	1210
	694003	**1,570**	**1,280**	**1,280**	**1,350**		
	694004	75.9	873	**1,250**	1,200		
	694005	254	270	307	218		
	694006	**1,610**	**1,660**	**1,360**	936		
	694007	**1,330**	**1,375**	953.5	1,095		
Mercury	694002	ND	**1.6**	ND	ND	1.1/2	NA
	694003	ND	ND	ND	**7.6**		
	694007	ND	1.1	ND	ND		

Table 10.6.8
AOCs 693 and 694
Analytes Detected in Shallow Groundwater

Parameter	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Tap-water RBC/MCL	Shallow Background
Nickel	694002	ND	19.3	0.73	ND	73/100	2.84
	694003	ND	ND	2	ND		
	694004	2.8	9.2	ND	8.3		
	694005	ND	ND	6.3	ND		
	694006	ND	ND	3.9	ND		
Potassium	694002	69,400	66,800	53,300	50,100	NL/NL	NA
	694003	80,000	74,200	64,700	72,500		
	694004	39,300	49,500	21,900	21,200		
	694005	81,200	77,200	70,000	55,100		
	694006	122,000	114,000	107,000	78,500		
	694007	110,000	919,500	87,100	86,550		
Selenium	694003	ND	ND	4	ND	18/50	NA
Silver	694002	ND	35.3	ND	ND	18/100	NA
Sodium	694002	1,440,000	1,440,000	1,070,000	895,000	NL/NL	NA
	694003	2,260,000	2,210,000	2,720,000	1,810,000		
	694004	63,300	66,700	38,600	26,900		
	694005	2,030,000	2,010,000	2,070,000	1,350,000		
	694006	3,360,000	3,470,000	4,710,000	2,100,000		
	694007	2,975,000	3,320,000	2,835,000	2,410,000		
Tin	694007	ND	367	ND	ND	2,200/NL	34.6
Vanadium	694002	4.6	6.2	3.4	3.8	26/NL	9.1
	694003	5.4	5	5.2	4.9		
	694004	5.5	3.8	ND	ND		
	694005	1.6	1.3	1.2	1.3		
	694006	1.6	ND	1.5	1.9		
	694007	1.135	1.3	1.45	1.3		
Zinc	694004	ND	ND	ND	33.6	1,100/5,000	NA

Notes:
Bold concentrations exceed the RBCs, SSL, and the zone background.
ND = Not detected/not determined
NA = Not applicable/not available/not analyzed
NL = Not listed

Volatile Organic Compounds in Groundwater

Four VOCs (MIBK, acetone, carbon disulfide, and trichloroethene) were detected in AOC 693 and 694 third- and fourth-round groundwater samples. Each compound was detected in only one sample, during one sampling round. Of these detections, only the fourth-round TCE detection (2.0 μg/L) exceeded the lower of an RBC or MCL. This concentration only slightly exceeded TCE tap-water RBC, but not exceed its MCL.

Semivolatile Organic Compounds in Groundwater

Two SVOCs (benzoic acid and naphthalene) were detected in third- and fourth-round groundwater samples collected at AOCs 693 and 694. Each compound was detected in only one sample, during one sampling round. Neither detection exceeded the applicable tap-water RBC; no MCL is available for these compounds.

Pesticides/PCBs in Groundwater

No pesticides or PCBs were detected in groundwater samples collected at AOCs 693 and 694.

Other Organic Compounds in Groundwater

Dioxins were detected in all four groundwater sampling rounds. No individual congener exceeded its tap-water RBC or MCL. Additionally, all TCDD TEQs calculated for each of the samples were below the tap-water RBC and MCL for TCDD. During the fifth round of sampling, no dioxins were detected in the filtered or unfiltered samples.

Inorganics in Groundwater

Twenty-three inorganics were detected in groundwater at AOCs 693 and 694. Eight exceeded the lower of an applicable RBC or MCL, and if available, the shallow background screening concentration: aluminum, arsenic, beryllium, cadmium, chromium, iron, manganese, and mercury.

Aluminum exceeded the 50 μg/L MCL only during the second sampling round (307 μg/L at location 694005 and 262 μg/L at 694006). Aluminum results for the first, third, and fourth rounds were nondetect. However, all detected concentrations were below the 3,700 μg/L RBC. No background concentration is available for aluminum.

Arsenic exceeded the 0.045 μg/L RBC and 50 μg/L MCL, and the 15.1 μg/L background concentration during all four sampling rounds. Figure 10.6.8 shows arsenic concentrations detected in shallow groundwater during all sampling rounds.

Beryllium was detected infrequently in groundwater. A single second-round detection (4.9 μg/L at location 694002) slightly exceeded the 4 μg/L MCL for beryllium. No background concentration is available for beryllium.

Cadmium was detected infrequently, but exceeded its RBC, MCL, and background concentration in round one and two samples; one was a duplicate sample. However, cadmium was not detected in the original sample collected during the same round and also was not detected in the first-round sample at that well or its duplicate. The highest concentration was detected during round two. Figure 10.6.9 shows the cadmium concentrations detected in shallow groundwater during all sampling rounds.

Chromium was detected infrequently in rounds one, two, and four. All round-two detections exceeded the 11 μg/L RBC. No background concentration is available for chromium. Figure 10.6.10 shows chromium detected in shallow groundwater during all sampling rounds.

Iron exceeded its background during all four sampling rounds. The highest detected concentration occurred during round two. Figure 10.6.11 shows iron detected in shallow groundwater during all sampling rounds.

Manganese was detected during all sampling rounds. Most concentrations exceeded the 73 μg/L RBC, 50 μg/L MCL and 1,210 μg/L shallow background concentration. NBCKGDKCL1, the well installed upgradient from the AOCs 693 and 694 area, contained 976 μg/L manganese, which also exceeds the RBC and MCL screening concentrations. The highest detected concentration occurred during round two. Figure 10.6.12 shows manganese detected in shallow groundwater during all sampling rounds.

Mercury was detected during rounds two and four. The round-two detection (1.6 μg/L at location 694002) exceeded the 1.1 μg/L RBC; the round-four detection (7.6 μg/L at location 694003) exceeded both the RBC and the 2.0 μg/L MCL.

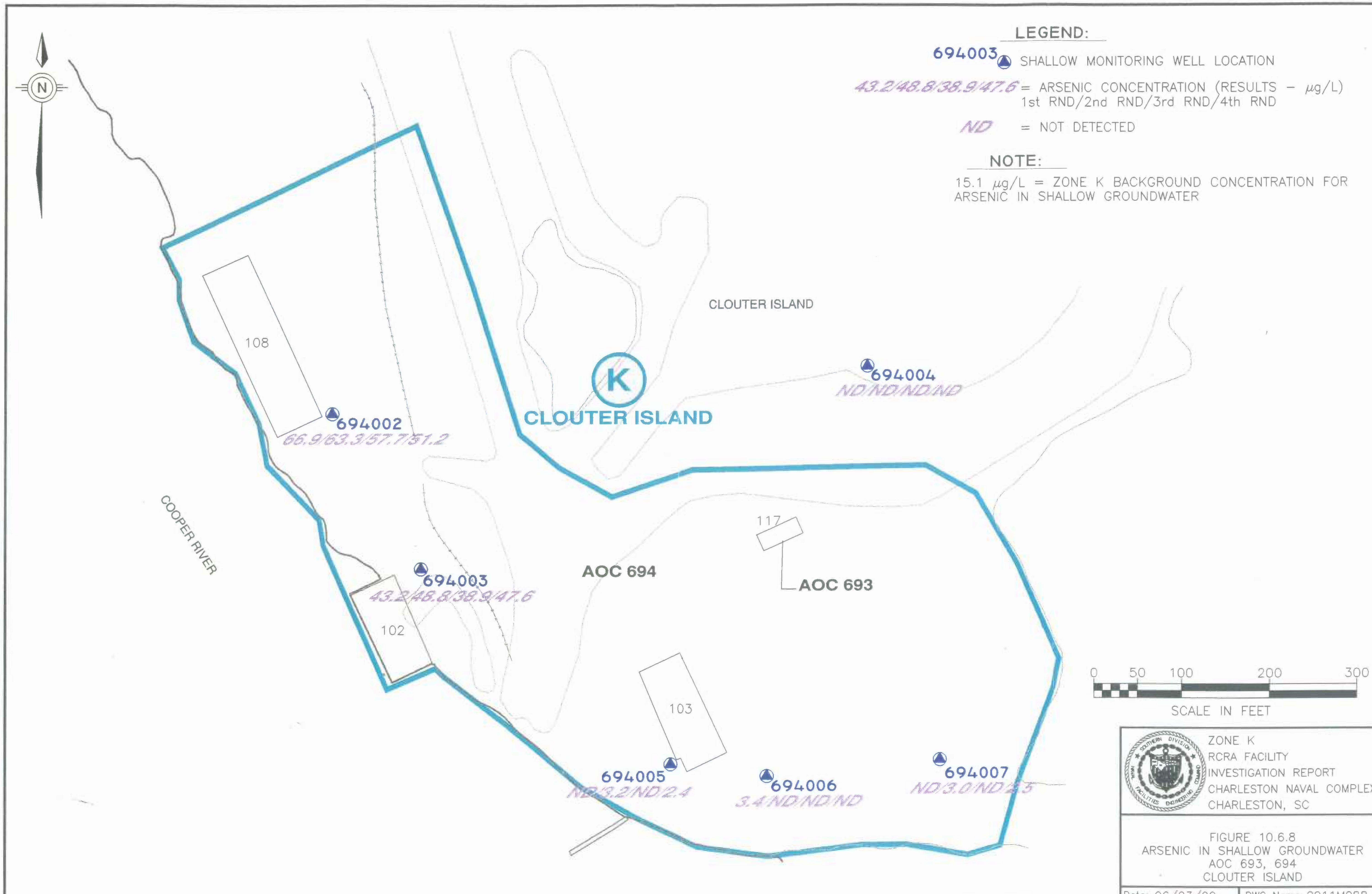
10.6.5 Fate and Transport Assessment for AOCs 693 and 694

Environmental media sampled as part of the AOCs 693 and 694 RFI include surface soil, subsurface soil, and shallow groundwater. Potential constituent migration pathways investigated for AOC 693 and 694 include soil to groundwater, groundwater-to-surface-water, and emission of volatiles from surface soil-to-air.

10.6.5.1 AOCs 693 and 694 — Soil-to-Groundwater Cross-media Transport

Tables 10.6.9 and 10.6.10 compare maximum detected organic and inorganic constituent concentrations in surface soil and subsurface soil samples to risk-based soil screening levels considered protective of groundwater. To provide a conservative screen, generic soil screening levels are used; leachate entering the aquifer is assumed to be diluted by a ratio of 10:1, with no attenuation of constituents in soil (DAF=10).

Three organic compounds - benzo(a)pyrene, delta BHC and dieldrin - were detected in AOC 693 and 694 soil at concentrations above their respective groundwater protection SSLs. Benzo(a)pyrene was above its RBC at 5 of 23 locations but was well below the SSL in subsurface

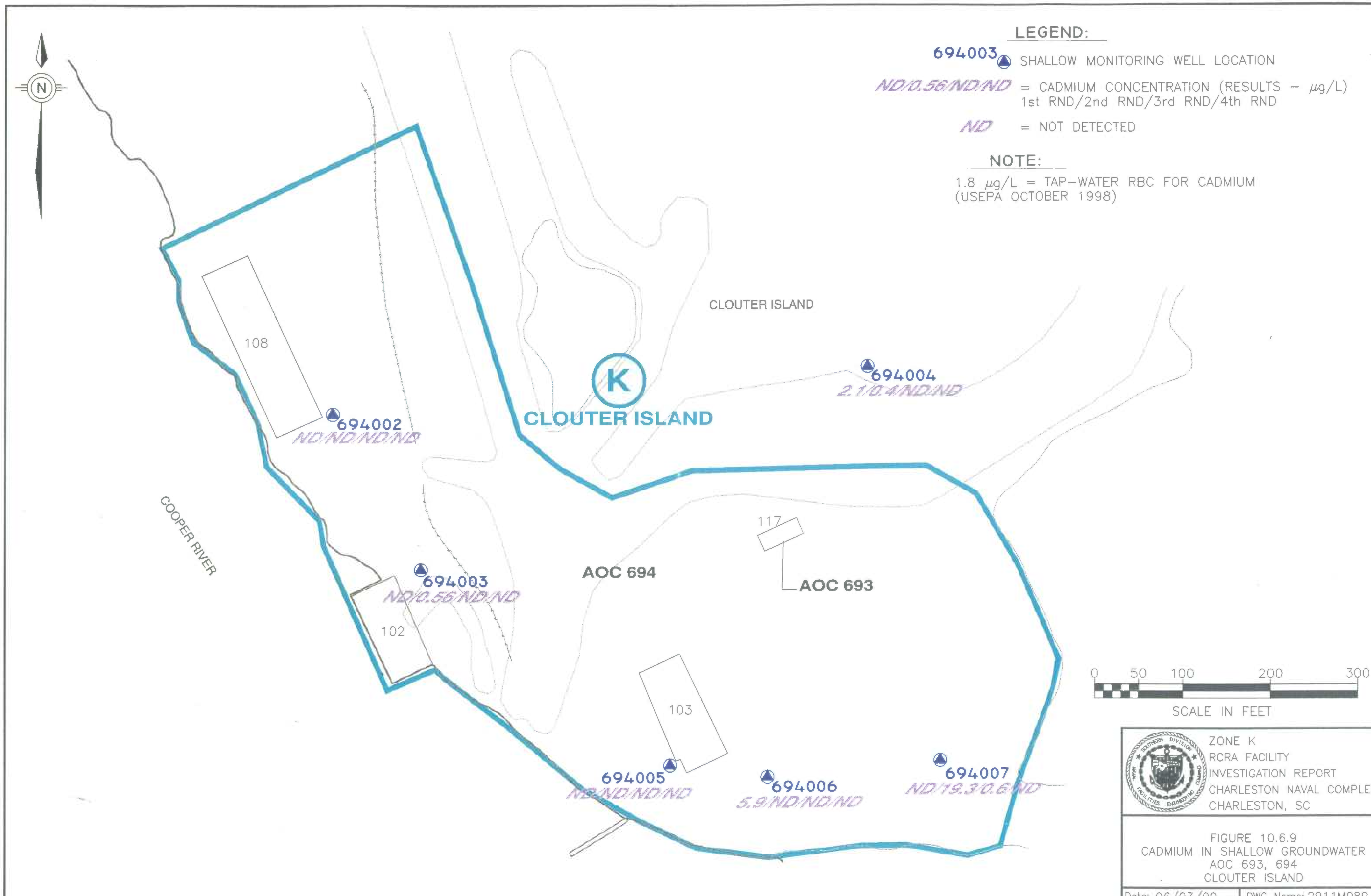


ZONE K
RCRA FACILITY INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.6.8
ARSENIC IN SHALLOW GROUNDWATER
AOC 693, 694
CLOUTER ISLAND

Date: 06/03/99 | DWG Name: 2911M088

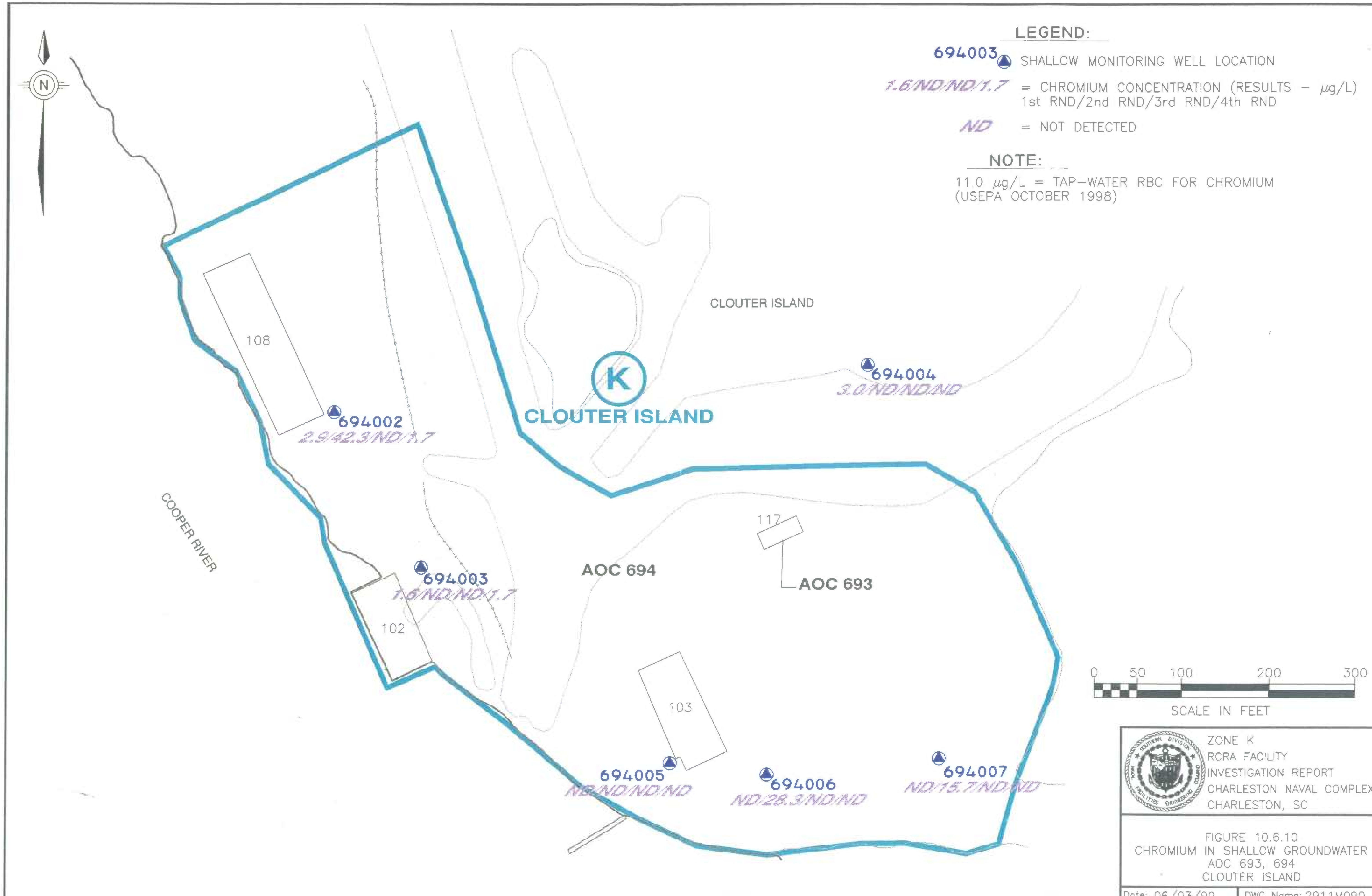
00149TB14Z



ZONE K
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.6.9
CADMIUM IN SHALLOW GROUNDWATER
AOC 693, 694
CLOUTER ISLAND

Date: 06/03/99 | DWG Name: 2911M089


LEGEND:
694003 SHALLOW MONITORING WELL LOCATION
1.6/ND/ND/1.7 = CHROMIUM CONCENTRATION (RESULTS – µg/L)
1st RND/2nd RND/3rd RND/4th RND
ND = NOT DETECTED
NOTE:
11.0 µg/L = TAP-WATER RBC FOR CHROMIUM
(USEPA OCTOBER 1998)
N
CLOUTER ISLAND
K
CLOUTER ISLAND
108
694002
2.9/42.3/ND/1.7
694004
3.0/ND/ND/ND
COOPER RIVER
694003
1.6/ND/ND/1.7
102
AOC 694
117
AOC 693
103
694005
ND/ND/ND/ND
694006
ND/28.3/ND/ND
694007
ND/15.7/ND/ND
0 50 100 200 300
SCALE IN FEET
ZONE K
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.6.10
CHROMIUM IN SHALLOW GROUNDWATER
AOC 693, 694
CLOUTER ISLAND
Date: 06/03/99
DWG Name: 2911M090

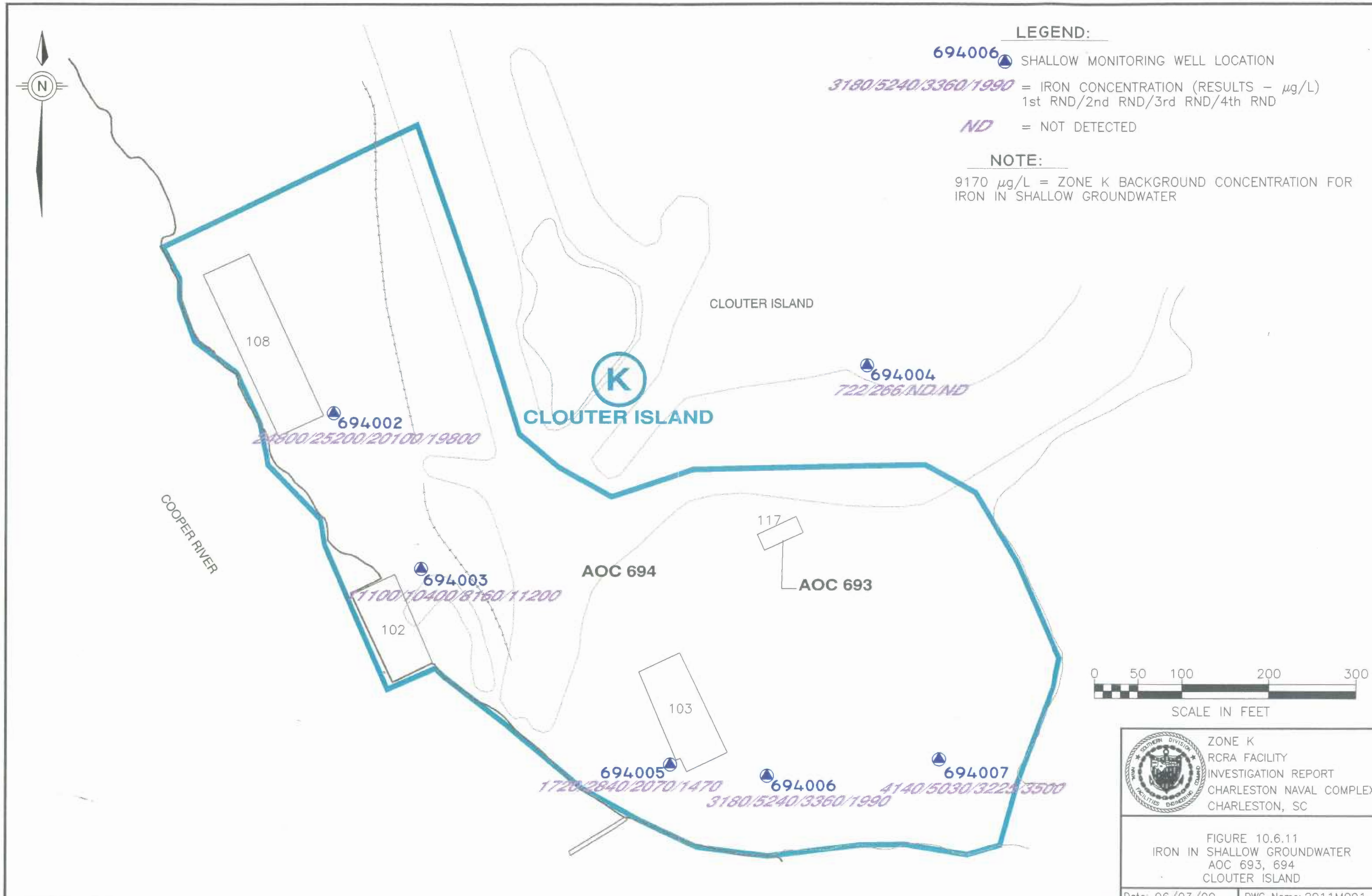
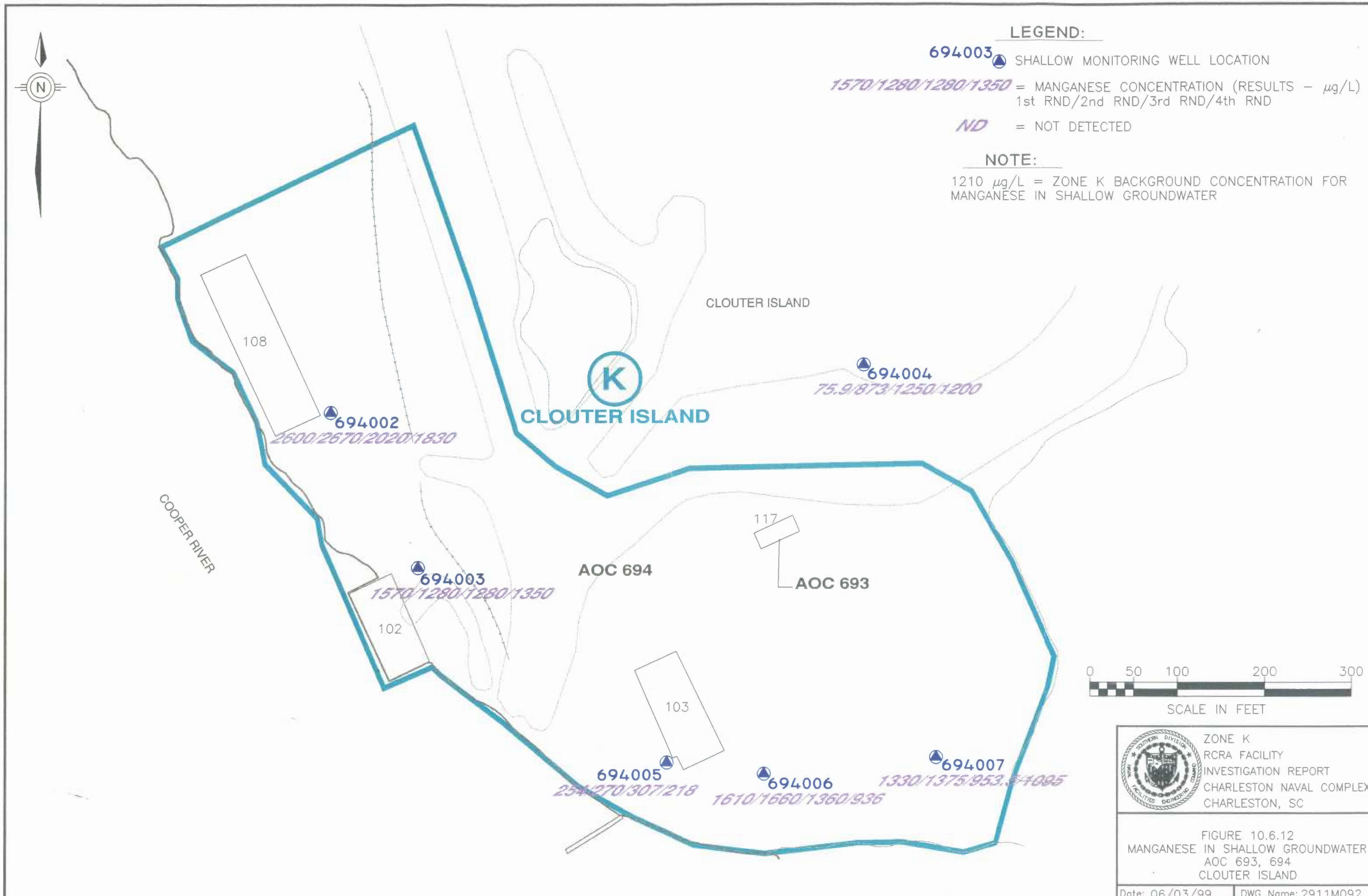


FIGURE 10.6.11
IRON IN SHALLOW GROUNDWATER
AOC 693, 694
CLOUTER ISLAND



N
LEGEND:
694003 SHALLOW MONITORING WELL LOCATION
1570/1280/1280/1350 = MANGANESE CONCENTRATION (RESULTS – µg/L)
1st RND/2nd RND/3rd RND/4th RND
ND = NOT DETECTED
NOTE:
1210 µg/L = ZONE K BACKGROUND CONCENTRATION FOR MANGANESE IN SHALLOW GROUNDWATER
CLOUTER ISLAND
K
CLOUTER ISLAND
108
694002
2600/2670/2020/1830
694004
75.9/873/1250/1200
COOPER RIVER
694003
1570/1280/1280/1350
102
AOC 694
117
AOC 693
103
694005
270/307/218
694006
1610/1660/1360/936
694007
1330/1375/953
0 50 100 200 300
SCALE IN FEET
ZONE K
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.6.12
MANGANESE IN SHALLOW GROUNDWATER
AOC 693, 694
CLOUTER ISLAND
Date: 06/03/99
DWG Name: 2911M092

Table 10.6.9
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, and Soil to Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: AOC 693 and AOC 694
Charleston, South Carolina

Parameter	Maximum Concentration			Screening Concentration *							
	Surface Soil	Subsurfac Soil	Shallow GW	Soil to GW SSL	Tap Water RBC	Soil to Air SSL	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Volatil-ization Potential
Volatile Organic Compounds											
Acetone				8000	3700	1E+08	UG/KG	UG/L	ERR	NO	NO
Benzene c				15	0.36	800	UG/KG	UG/L	ERR	NO	NO
Bromodichloromethane c				300	0.17	3000000	UG/KG	UG/L	ERR	NO	NO
2-Butanone (MEK)				3900 a	1900	10000	UG/KG	UG/L	ERR	NO	NO
Carbon disulfide				16000	1000	720000	UG/KG	UG/L	ERR	NO	NO
Chloroform c				300	0.15	300	UG/KG	UG/L	ERR	NO	NO
Chloromethane c				3.7 a	1.5	63	UG/KG	UG/L	ERR	NO	NO
1,2-Dichloroethane (EDC) c				10	0.12	400	UG/KG	UG/L	ERR	NO	NO
1,1-Dichloroethene c				30	0.044	70	UG/KG	UG/L	ERR	NO	NO
cis-1,2-Dichloroethene				200	61	1200000	UG/KG	UG/L	ERR	NO	NO
trans-1,2-Dichloroethene				350	120	3100000	UG/KG	UG/L	ERR	NO	NO
1,2-Dichloroethene (total)				200 b	55	1200000	UG/KG	UG/L	ERR	NO	NO
Ethylbenzene				6500	1300	400000	UG/KG	UG/L	ERR	NO	NO
2-Hexanone				3700 a	1500	10000	UG/KG	UG/L	ERR	NO	NO
Methylene chloride c				10	4.1	13000	UG/KG	UG/L	ERR	NO	NO
1,1,2,2-Tetrachloroethane c				1.5	0.053	600	UG/KG	UG/L	ERR	NO	NO
Tetrachloroethene (PCE) c				30	1.1	11000	UG/KG	UG/L	ERR	NO	NO
Trichloroethene (TCE) c				30	1.6	5000	UG/KG	UG/L	ERR	NO	NO
Vinyl chloride c				5	0.019	30	UG/KG	UG/L	ERR	NO	NO
Xylene (total)				70000 a	12000	410000	UG/KG	UG/L	ERR	NO	NO
Semivolatile Organic Compounds											
Acenaphthene				290000	2200	NA	UG/KG	UG/L	ERR	NO	NO
Acenaphthylene				47000 a	730	NA	UG/KG	UG/L	ERR	NO	NO
Anthracene				6000000	11000	NA	UG/KG	UG/L	ERR	NO	NO
Benzo(g,h,i)perylene				5.7E+07 a	730	NA	UG/KG	UG/L	ERR	NO	NO
Benzo(a)pyrene equivalents (BEQs) c				NA	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)anthracene c				800	0.092	NA	UG/KG	UG/L	ERR	NO	NO
Benzo(a)pyrene c				4000	0.0092	NA	UG/KG	UG/L	ERR	NO	NO
Benzo(b)fluoranthene c				2300 a	0.092	NA	UG/KG	UG/L	ERR	NO	NO
Benzo(k)fluoranthene c				25000	0.92	NA	UG/KG	UG/L	ERR	NO	NO
Chrysene c				80000	9.2	NA	UG/KG	UG/L	ERR	NO	NO
Dibenzo(a,h)anthracene c				800	0.0092	NA	UG/KG	UG/L	ERR	NO	NO
Indeno(1,2,3-cd)pyrene c				7000	0.092	NA	UG/KG	UG/L	ERR	NO	NO
Butylbenzylphthalate c				930000	7300	930000	UG/KG	UG/L	ERR	NO	NO
Carbazole c				300	3.3	NA	UG/KG	UG/L	ERR	NO	NO
Dibenzofuran				6800 a	24	120000	UG/KG	UG/L	ERR	NO	NO
Di-n-butylphthalate				2300000	3700	2300000	UG/KG	UG/L	ERR	NO	NO
bis(2-Ethylhexyl)phthalate (BEHP) c				1800000	4.8	3.1E+07	UG/KG	UG/L	ERR	NO	NO
Fluoranthene				2100000	1500	NA	UG/KG	UG/L	ERR	NO	NO
Fluorene				280000	1500	NA	UG/KG	UG/L	ERR	NO	NO
2-Methylnaphthalene				18000 a	120	NA	UG/KG	UG/L	ERR	NO	NO
4-Methylphenol (p-cresol)				670 a	180	NA	UG/KG	UG/L	ERR	NO	NO
Naphthalene				31000 a	730	NA	UG/KG	UG/L	ERR	NO	NO
N-Nitroso-di-n-propylamine c				0.024 a	0.0096	NA	UG/KG	UG/L	ERR	NO	NO
Phenanthrene				660000 a	1100	NA	UG/KG	UG/L	ERR	NO	NO
Phenol				50000	22000	NA	UG/KG	UG/L	ERR	NO	NO
Pyrene				2100000	1100	NA	UG/KG	UG/L	ERR	NO	NO
Pesticides/PCB Compounds											
Aldrin c				200	0.004	3000	UG/KG	UG/L	ERR	NO	NO
Aroclor-1254 c				1000	0.033	1000	UG/KG	UG/L	ERR	NO	NO
Aroclor-1260 c				1000	0.033	1000	UG/KG	UG/L	ERR	NO	NO
delta-BHC c				1.8 a	0.037	NA	UG/KG	UG/L	ERR	NO	NO
alpha-Chlordane c				5000 b	0.19	20000	UG/KG	UG/L	ERR	NO	NO
gamma-Chlordane c				5000 b	0.19	20000	UG/KG	UG/L	ERR	NO	NO
4,4'-DDD c				8000	0.28	NA	UG/KG	UG/L	ERR	NO	NO
4,4'-DDE c				27000	0.2	NA	UG/KG	UG/L	ERR	NO	NO
4,4'-DDT c				16000	0.2	1.0E+09	UG/KG	UG/L	ERR	NO	NO
Dieldrin c				2	0.0042	1000	UG/KG	UG/L	ERR	NO	NO

Table 10.6.9
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, and Soil to Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: AOC 693 and AOC 694
Charleston, South Carolina

	Maximum Concentration			Screening Concentration *						Ground-	
				Soil to		Soil to				Water	Volatil-
	Surface	Subsurfac	Shallow	GW	Tap Water	Air	Soil	Water	Leaching	Migration	ization
Parameter	Soil	Soil	GW	SSL	RBC	SSL	Units	Units	Potential	Concern	Potential
Endosulfan II				9000 b	220	NA	UG/KG	UG/L	ERR	NO	NO
Endosulfan sulfate				4600 a	220	NA	UG/KG	UG/L	ERR	NO	NO
Endrin				500	11	NA	UG/KG	UG/L	ERR	NO	NO
Endrin aldehyde				340 a	11	NA	UG/KG	UG/L	ERR	NO	NO
Endrin ketone				340 a	11	NA	UG/KG	UG/L	ERR	NO	NO
Heptachlor c				11000	0.0023	100	UG/KG	UG/L	ERR	NO	NO
Heptachlor epoxide c				330	0.0012	5000	UG/KG	UG/L	ERR	NO	NO
Dioxin Compounds											
2378-TCDD Equivalents (TEQs) c				1600 a	0.45	NA	NG/KG	PG/L	ERR	NO	NO
2378-TCDD c				1600 a	0.45	NA	NG/KG	PG/L	ERR	NO	NO
12378-PeCDD c				61 a	0.89	NA	NG/KG	PG/L	ERR	NO	NO
123478-HxCDD c				4100 a	4.5	NA	NG/KG	PG/L	ERR	NO	NO
123678-HxCDD c				4100 a	4.5	NA	NG/KG	PG/L	ERR	NO	NO
123789-HxCDD c				4100 a	4.5	NA	NG/KG	PG/L	ERR	NO	NO
1234678-HpCDD c				110000 a	45	NA	NG/KG	PG/L	ERR	NO	NO
OCDD c				1100000 a	450	NA	NG/KG	PG/L	ERR	NO	NO
2378-TCDF c				240 a	4.5	NA	NG/KG	PG/L	ERR	NO	NO
12378-PeCDF c				770 a	8.9	NA	NG/KG	PG/L	ERR	NO	NO
23478-PeCDF c				120 a	0.89	NA	NG/KG	PG/L	ERR	NO	NO
123478-HxCDF c				220000 a	4.5	NA	NG/KG	PG/L	ERR	NO	NO
123678-HxCDF c				220000 a	4.5	NA	NG/KG	PG/L	ERR	NO	NO
234678-HxCDF c				220000 a	4.5	NA	NG/KG	PG/L	ERR	NO	NO
123789-HxCDF c				220000 a	4.5	NA	NG/KG	PG/L	ERR	NO	NO
1234678-HpCDF c				54000 a	45	NA	NG/KG	PG/L	ERR	NO	NO
1234789-HpCDF c				54000 a	45	NA	NG/KG	PG/L	ERR	NO	NO
OCDF c				540000 a	450	NA	NG/KG	PG/L	ERR	NO	NO
TPH - Diesel Range Organics											
Diesel				NA	NA	NA	UG/KG	UG/L	NO	NO	NO
TPH - Gasoline Range Organics											
Gasoline				NA	NA	NA	UG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.6
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.X and 10.X.

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Based on surrogate compound (See Table 5.6)
c - Carcinogen
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration

SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.6.10
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Soil to Air SSLs, Tap Water RBCs, Background Reference Values, and Saltwater Surface Water Chronic Screening Levels
Charleston Naval Complex, Zone K, Clouter Island: AOCs 693 and 694
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurface Soil	Shallow GW	Screening Concentration Soil to GW SSL	Soil Background Reference	Soil to Air SSL	Tap Water RBC	GW Background Reference	Saltwater Surf. Wtr. Chronic	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Fugitive Particulate Inhalation Concern	Surface Water Migration Concern
Inorganics															
Aluminum	44700	38500	307	560000 a	32100	NA	37000	NA	NA	MG/KG	UG/L	NO	NO	NO	NO
Antimony	27.9	4.7	ND	2.7	2.16	NA	15	NA	NA	MG/KG	UG/L	YES	NO	NO	NO
Arsenic c	25.8	21.6	66.9	15	23	750	0.045	15.1	36	MG/KG	UG/L	YES	YES	NO	YES
Barium	131	44.6	71	820	67.1	690000	2600	95.9	NA	MG/KG	UG/L	NO	NO	NO	NO
Beryllium	1.6	1.5	4.9	32	1.35	1300	73	NA	NA	MG/KG	UG/L	NO	NO	NO	NO
Cadmium	1.5	1.1	19.3	3.8	0.55	1800	18	0.4	9.3	MG/KG	UG/L	NO	YES	NO	YES
Chromium (total)	77.3	64	42.3	1000000	69.1	270	110 b	NA	50	MG/KG	UG/L	NO	NO	NO	NO
Cobalt	10.1	11.7	18.9	990 a	5.7	NA	2200	NA	NA	MG/KG	UG/L	NO	NO	NO	NO
Copper	1020	126	54.7	5600 a	119	NA	1500	5.8	2.9	MG/KG	UG/L	NO	NO	NO	YES
Cyanide	ND	ND	2	20	NA	NA	730	NA	1	MG/KG	UG/L	NO	NO	NO	YES
Lead	481	106	2.7	400 d	98.3	400	15	NA	8.5	MG/KG	UG/L	YES	NO	YES	NO
Manganese	738	747	2670	480 a	1210	NA	730	1210	NA	MG/KG	UG/L	YES	YES	NO	NO
Mercury	1.7	1.4	7.6	1	0.63	10	11	NA	0.025	MG/KG	UG/L	YES	NO	NO	YES
Nickel	37.1	22.5	19.3	65	24.5	13000	730	2.8	8.3	MG/KG	UG/L	NO	NO	NO	YES
Selenium	4.7	1.3	4	2.6	1.24	NA	180	NA	71	MG/KG	UG/L	YES	NO	NO	NO
Silver	1.2	0.33	35.3	17	0.41	NA	180	NA	0.23	MG/KG	UG/L	NO	NO	NO	YES
Tin	284	73.3	367	5500 a	39.1	NA	22000	34.6	NA	MG/KG	UG/L	NO	NO	NO	NO
Vanadium	92.2	81.4	6.2	3000	75.9	NA	260	9.1	NA	MG/KG	UG/L	NO	NO	NO	NO
Zinc	792	341	33.6	6200	236	NA	11000	NA	86	MG/KG	UG/L	NO	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.8
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.6.3 and 10.6.7.

Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration concern.

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Assumes hexachrome
c - Carcinogen
d - USEPA de facto residential soil level
GW - Groundwater
NA - Not available/Not applicable

ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

soil. Delta BHC was detected at one surface soil location, and was nondetect in subsurface soil. Furthermore, it was not detected in site groundwater. As a result, the pathway is not considered valid for this parameter. Dieldrin was detected at four soil boring locations in the vicinity of Building 106 within the AOC 694 area. Three of the reported detections exceeded dieldrin's SSL. At one of the locations (694SB011) dieldrin was detected at 4.82 μg/kg in the lower-interval sample. At two of the other three locations (8.06 μg/kg at 694SB014 and 9.2 μg/kg at 694SB018), only the upper-interval sample was collected; no measure of dieldrin's presence in the lower-interval at these locations is available. At the fourth location (694SB016), dieldrin was detected in the upper-interval sample (3.89 μg/kg) but not the lower-interval sample. Dieldrin was not detected in the groundwater samples collected in the AOCs 693 and 694 area, thus this pathway is not considered valid for this parameter.

Six inorganics in soil exceeded their groundwater protection SSLs: antimony, arsenic, chromium, lead, manganese, and mercury. Antimony was detected at three locations at concentrations greater than its groundwater protection screening level. The greatest exceedance was in the upper-interval sample at 694SB012. Antimony was not detected in groundwater, thus the pathway is not considered valid.

Arsenic was detected above its SSL at numerous locations above its SSL in surface soil, but only two locations in subsurface soil. In groundwater, arsenic exceeded its screening concentration in only one location. These data suggest that the pathway is valid, but is not expected to be significant with respect to arsenic.

The bulk of chromium detections were above the SSL in both surface and subsurface locations. In groundwater, it was detected in approximately half of sampled locations, but was below the screening concentration. These data indicate that the pathway is valid, but due to the lack of groundwater exceedances is not considered significant.

Lead was present at a concentration greater than its screening level in only one surface sample, 694SB00901. The concentration of lead in this sample (481 mg/kg) was only slightly higher than the screening concentration (400 mg/kg). In groundwater, lead was present but was well below its RBC. As a result, this pathway is considered valid, but not significant.

Manganese was detected above its SSL in a number of surface soil locations, but only one subsurface location exceeded the SSL. In groundwater, manganese was widely detected, and was above its RBC and background concentration in five of six locations. The presence of manganese above its SSL in only one subsurface location, but above the groundwater criteria in most of the sampled locations suggest that the calculated SSL is either too high (and manganese leaches to groundwater above standards from a lower soil concentration), the DAF is too high, or that some leaching is occurring from aquifer matrix (or a combination of these). At any rate, the pathway is considered valid, but is not significant simply due to non-use of the groundwater resource.

Mercury was detected above the SSL at only one location. In groundwater, it was detected in two of six sampling locations, but was well below the RBC. Therefore, this pathway is considered valid but not significant.

10.6.5.2 AOCs 693 and 694 — Risk-based Groundwater Transport and Surface Water Cross-media Transport

Tables 10.6.9 and 10.6.10 also compare maximum detected organic and inorganic constituent concentrations in shallow groundwater samples to risk-based concentrations for drinking water, and to chronic ambient saltwater quality criteria values for the protection of aquatic life (saltwater surface water chronic screening values). To provide a conservative screen, no attenuation or dilution of constituents in groundwater is assumed before comparison to the relevant standards. It should be noted that the risk-based pathway is not considered significant at these AOCs due to non-use of the groundwater as a potable resource.

One organic compound — TCE — exceeded its RBC at one locations during fourth-round sampling.

Three inorganics — arsenic, cadmium, and manganese — were detected in AOCs 693 and 694 groundwater above risk-based drinking water concentrations.

All reported detections of arsenic in groundwater samples from all four sampling rounds exceeded its tap-water RBC of 0.045 μg/L, including the one from the up gradient monitoring well.

Cadmium was detected in only one well at a concentration exceeding the tap-water RBC, in a duplicate sample collected during the second round of sampling. Cadmium was not detected in any of the fourth-round samples, thus the pathway is considered invalid.

Manganese concentrations in groundwater exceeded the RBC in all wells for all rounds.

No organics exceeded the surface water screening criteria, while seven inorganics exceeded their respective surface water criteria. Groundwater flow patterns indicate that groundwater-to-surface-water discharge is a valid pathway as a first screen, but it is notable that this screening does not quantify or account for attenuation of concentrations by dilution upon discharge.

Seven inorganics - arsenic, cadmium, copper, cyanide, mercury, nickel, and silver - were detected in groundwater at concentrations exceeding their respective saltwater/surface water chronic screening values. Cyanide and silver were both nondetect in the last quarter of sampling, thus the pathway for them is considered invalid.

10.6.5.3 AOC 693 and AOC 694 — Soil-to-air Cross-media Transport

Table 10.6.9 provides a comparison between VOCs detected in surface soil and soil-to-air screening values. No VOCs were detected in surface soil samples collected at AOCs 693 and 694 at concentrations exceeding the soil-to-air screening level.

10.6.5.4 AOC 693 and AOC 694 — Fate and Transport Summary

Three organics were present above their SSLs in soil but were not detected in groundwater. As a result, the pathway is not considered valid for them.

Six inorganics were present in soil above their SSLs.

Antimony was above its SSL, but was not detected in groundwater; thus the pathway is considered invalid for it. Arsenic, chromium, lead, manganese, and mercury were also above their SSLs, and were detected in groundwater. The pathway for these is considered valid, but due to a lack of spatial persistence in groundwater (indicating only a small mass of affected groundwater), is not expected to be significant.

One organic and three inorganics were present in groundwater above their RBCs. TCE was detected at one location during the third and fourth-rounds slightly above the RBC; arsenic and manganese were widespread above their RBCs; and cadmium, which exhibited an exceedance in the first and second-rounds, was not detected in the fourth. The risk-based pathway is not considered valid simply due to non-use of the resource.

The surface water pathway presents an element of validity from a hydrologic standpoint. Seven inorganics, but no organics, exceeded surface water criteria. Arsenic, cadmium, copper, cyanide, mercury and silver exceedances validate the pathway. However, cyanide and silver were both nondetect in the fourth-round of sampling, thus the pathway for them is considered invalid.

No other fate and transport concerns were identified at these sites.

10.6.6 Human Health Risk Assessment for Combined AOCs 693 and 694

10.6.6.1 Site Background and Investigative Approach

AOC 693 consists of former Building 117, a previous fuse and primer house located in a wooded area adjacent to the Clouter Creek Dredge Area on Clouter Island. AOC 694 is a former Naval Ammunition Depot, which consists of the area surrounding former Building 117. Due to their proximity and similar histories, these AOCs were investigated together.

During the RFI, 27 soil samples in all were collected from the upper-interval, and 12 were collected from the lower-interval to identify potential impacts resulting from the activities at the AOCs. Surface soil samples from all 23 boring locations were used to quantitatively assess soil exposure pathways. Subsurface soil is addressed in the previous section for AOCs 693 and 694. Seven temporary monitoring wells were installed in the shallow aquifer. Six of them are between the areas identified as AOC 693 and AOC 694 and the Cooper River. The seventh is upgradient of the area, and considered a background location. Data from all four groundwater sampling rounds were used to quantitatively assess groundwater exposure pathways. Sections 10.6.1 and 10.6.3 summarize the sampling effort for AOCs 693 and 694 soil and groundwater.

10.6.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.6.11, the following were identified as COPCs in surface soil: benzo(a)pyrene equivalent compounds, aluminum, antimony, arsenic, chromium, copper, lead, vanadium, and Aroclor-1260. Wilcoxon rank sum test analysis did not result in the inclusion of any inorganic parameter that had been screened out on the basis of background comparisons only.

Table 10.6.11
Chemicals Present in Site Samples
AOCs 693 and 694 - Surface Soil
Naval Base Charleston, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
Carcinogenic PAHs													
B(a)P Equiv.	*	6	23	18.8	535.46	246	439.09	589.305	88	NA	UG/KG	5	
Benzo(a)anthracene		4	23	87	480	264	190	255	880	NA	UG/KG		
Benzo(a)pyrene	*	5	23	89	440	234	185	255	88	NA	UG/KG	5	
Benzo(b)fluoranthene		6	23	100	450	272	190	255	880	NA	UG/KG		
Benzo(k)fluoranthene		4	23	130	180	158	185	255	8800	NA	UG/KG		
Chrysene		6	23	99	660	260	190	255	88000	NA	UG/KG		
Indeno(1,2,3-cd)pyrene		2	23	130	160	145	185	255	880	NA	UG/KG		
TCDD Equivalents													
1234678-HpCDD		26	27	2.26	298.998	63.34	0.4905	0.4905	NA	NA	NG/KG		
1234678-HpCDF		24	27	0.402	27.641	7.29	0.3965	1.28	NA	NA	NG/KG		
1234789-HpCDF		1	27	1.03	1.03	1.03	0.1125	5.869	NA	NA	NG/KG		
123478-HxCDD		2	27	0.889	1.72	1.27	0.129	3.91	NA	NA	NG/KG		
123478-HxCDF		18	27	0.446	9.103	2.91	0.1435	0.9185	NA	NA	NG/KG		
123678-HxCDD		19	27	0.693	7.91	3.46	0.1985	0.375	NA	NA	NG/KG		
123678-HxCDF		2	27	2.004	5.669	3.84	0.083	0.515	NA				
123789-HxCDD		18	27	0.818	9.308	2.95	0.2165	0.52	NA	NA	NG/KG		
12378-PeCDF		5	27	0.585	1.716	1.34	0.0945	0.595	NA	NA	NG/KG		
2378-TCDD		1	27	0.174	0.174	0.17	0.1465	0.4215	NA				
2378-TCDF		4	27	0.77	2.37	1.23	0.113	0.5625	NA	NA	NG/KG		
Dioxin Equiv.		27	27	0.0057	9.5	1.96	NA	NA	1000[a]	NA	NG/KG		
OCDD		27	27	5.76	3313	556.48	NA	NA	NA	NA	NG/KG		
OCDF		25	27	0.396	139.893	21.54	0.545	0.56	NA	NA	NG/KG		
Inorganics													
Aluminum (Al)	*	27	27	1370	44700	19954	NA	NA	7800	32100	MG/KG	22	5
Antimony (Sb)	*	17	27	0.56	27.9	3.42	0.15	0.2	3.1	2.16	MG/KG	5	7
Arsenic (As)	*	25	27	7.2	25.8	13.90	2.25	2.25	0.43	23	MG/KG	25	1
Barium (Ba)		27	27	4.9	131	35.20	NA	NA	550	67.1	MG/KG		1
Beryllium (Be)		27	27	0.1	1.6	0.89	NA	NA	16	1.35	MG/KG		3
Cadmium (Cd)		23	27	0.22	1.5	0.43	0.1	0.13	3.9	0.55	MG/KG		3
Calcium (Ca)		27	27	4470	100000	36937	NA	NA	NA	NA	MG/KG		
Chromium (Cr)	*	27	27	4.8	77.3	48.30	NA	NA	23	69.1	MG/KG	25	4
Cobalt (Co)		27	27	0.97	10.1	4.96	NA	NA	470	5.7	MG/KG		8
Copper (Cu)	*	27	27	4.3	1020	89.90	NA	NA	310	119	MG/KG	1	3
Iron (Fe)		27	27	2170	43200	23232	NA	NA	2300	35200	MG/KG		
Lead (Pb)	*	27	27	5.3	481	84.20	NA	NA	400	98.3	MG/KG	1	6
Magnesium (Mg)		27	27	355	6700	3786	NA	NA	NA	NA	MG/KG		
Manganese (Mn)		27	27	83.5	738	381	NA	NA	1100	764	MG/KG	19	
Mercury (Hg)		25	27	0.11	1.7	0.36	0.025	0.035	2.3	0.63	MG/KG		2
Nickel (Ni)		27	27	1.7	37.1	16.80	NA	NA	160	24.5	MG/KG		2
Potassium (K)		27	27	172	5800	1981	NA	NA	NA	NA	MG/KG		
Selenium (Se)		9	27	0.69	4.7	1.58	0.24	1.45	39	1.24	MG/KG		3
Silver (Ag)		15	27	0.31	1.2	0.62	0.13	0.175	39	0.41	MG/KG		13
Sodium (Na)		27	27	167	5130	1132	NA	NA	NA	NA	MG/KG		
Tin (Sn)		14	27	5.9	284	53.60	5.2	6.95	4700	39.1	MG/KG		3
Vanadium (V)	*	27	27	4.3	92.2	47.50	NA	NA	55	75.9	MG/KG	10	3
Zinc (Zn)		26	27	38.9	792	210	6.5	6.5	2300	236	MG/KG		5
Pesticides/PCBs													
Aroclor-1260	*	14	23	26	596	112	18.25	25.7	320	NA	UG/KG	1	
4,4'-DDD		3	23	4.74	54.8	21.8	1.825	2.57	2700	NA	UG/KG		
4,4'-DDE		3	23	4.72	14	9.0	1.825	2.57	1900	NA	UG/KG		
4,4'-DDT		3	23	14.3	70	34.4	1.825	2.57	1900	NA	UG/KG		
Aldrin		2	23	3.03	8.44	5.7	0.94	1.325	38	NA	UG/KG		
alpha-Chlordane		1	23	9.91	9.91	9.9	0.94	1.325	470	NA	UG/KG		
delta-BHC		1	23	2.62	2.62	2.6	0.94	1.325	100	NA	UG/KG		
Dieldrin		3	23	3.89	9.2	7.1	1.825	2.57	40	NA	UG/KG		
Endosulfan II		1	23	10.9	10.9	10.9	1.825	2.57	47000	NA	UG/KG		
Endrin		5	23	5.2	36.2	12.6	1.825	2.57	2300	NA	UG/KG		
Endrin aldehyde		2	23	6	20.9	13.5	1.825	2.57	2300	NA	UG/KG		
Heptachlor epoxide		7	23	2.56	54.7	16.4	0.95	1.325	70	NA	UG/KG		

Table 10.6.11
Chemicals Present in Site Samples
AOCs 693 and 694 - Surface Soil
Naval Base Charleston, Zone K
Charleston, South Carolina

Parameter	Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
Semivolatile Organics												
Anthracene	1	23	110	110	110	185	255	2300000	NA	UG/KG		
Benzo(g,h,i)perylene	1	23	180	180	180	185	255	310000	NA	UG/KG		
bis(2-Ethylhexyl)phthalate (BEHP)	2	23	420	620	520	190	255	46000	NA	UG/KG		
Butylbenzylphthalate	1	23	680	680	680	185	255	1600000	NA	UG/KG		
Fluoranthene	5	23	87	710	317	190	255	310000	NA	UG/KG		
Phenanthrene	2	23	140	750	445	185	255	310000	NA	UG/KG		
Pyrene	6	23	91	1100	362	190	255	230000	NA	UG/KG		
Volatile Organics												
Acetone	1	23	2	2	2	5	7.5	780000	NA	UG/KG		
Carbon disulfide	1	23	4	4	4	2.5	3.5	780000	NA	UG/KG		

Notes:
* - Indicates chemical was identified as a COPC
a - Reported soil concentrations of dioxins (as TEQs) were compared to the project screening level.
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/KG - micrograms per kilogram
NG/KG - nanograms per kilogram
MG/KG - milligrams per kilogram
NA - Not applicable or not available

Groundwater

As shown in Table 10.6.12, arsenic, cadmium, and manganese were identified as a COPCs for shallow groundwater at AOCs 693 and 694. Silver was detected once in the second-round; trichloroethene was detected once in the fourth-round. Each was eliminated from consideration in the risk assessment because they were detected in fewer than 5% of the groundwater samples.

10.6.6.3 Exposure Assessment

Exposure Setting

AOCs 693 and 694 are adjacent to the Clouter Creek Drainage Area on Clouter Island in a wooded area. It is bounded to the north by a dike, which separates the site from the Clouter Creek Drainage Area, and to the south by the Cooper River shoreline.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed quantitatively in this risk assessment. Current exposure to workers is discussed qualitatively in relation to the future workers and future residents. The hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact (the concrete surface would prevent direct contact to a portion of the site). Therefore, future worker assessment is considered to conservatively represent current site users. The future site resident scenario was built on the premise that existing fixtures would be removed and replaced with dwellings.

Table 10.6.12
Chemicals Present In Site Samples
AOCs 693 and 694 - Groundwater
Naval Base Charleston, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Tap Water RBC	Reference	Units	Number Exceeding RBC	Ref
TCDD Equivalents													
Dioxin Equiv.		24	24	0.0026	0.23	0.04629	NA	NA	0.43	NA	PG/L		
Inorganics													
Aluminum (Al)		2	24	262	307	285	8	274	3700	NA	UG/L		
Arsenic (As)	*	13	24	2.4	66.9	33.2	2.1	27.8	0.045	15.1	UG/L	13	11
Barium (Ba)		23	24	17.4	71	39.3	NA	NA	260	95.9	UG/L		
Cadmium (Cd)	*	6	24	0.4	19.3	6.88	0.22	2.2	1.8	0.4	UG/L	3	5
Calcium (Ca)		24	24	143000	445000	250786	NA	NA	NA	NA	UG/L		
Chromium (Cr)		8	24	1.6	42.3	9.88	0.67	4.7	11	NA	UG/L	3	
Copper (Cu)		5	24	12	54.7	28.2	1	14.9	150	5.78	UG/L		5
Cyanide (CN)		1	24	2	2	2	2	10	73	NA	UG/L		
Iron (Fe)		22	24	266	25200	7131	74.9	459	NA	NA	UG/L		
Lead (Pb)		4	24	0.98	2.7	1.9	0.9	16.7	15	NA	UG/L		
Magnesium (Mg)		24	24	69300	402000	221964	NA	NA	NA	NA	UG/L		
Manganese (Mn)	*	24	24	75.9	2670	1219	NA	NA	84	1210	UG/L	23	15
Mercury (Hg)		2	24	1.1	7.6	3	0.08	3.7	1.1	NA	UG/L	1	
Nickel (Ni)		8	24	0.73	19.3	6.6	0.67	10.5	73	2.84	UG/L		5
Potassium (K)		24	24	21200	919500	134793	NA	NA	NA	NA	UG/L		
Selenium (Se)		1	24	4	4	4	3	34.4	18	NA	UG/L		
Silver (Ag)	*	1	24	35.3	35.3	35.3	0.89	8.9	18	NA	UG/L	1	
Sodium (Na)		24	24	26900	4710000	2079303	NA	NA	NA	NA	UG/L		
Tin (Sn)		1	24	367	367	367	14	38.2	2200	34.6	UG/L		1
Vanadium (V)		21	24	1.135	6.2	2.80	NA	NA	26	9.1	UG/L		
Zinc (Zn)		1	24	33.6	33.6	33.60	5.8	99.2	1100	NA	UG/L		
Semivolatile Organics													
Benzoic acid		1	24	6	6	6	50	71	15000	NA	UG/L		
Naphthalene		1	23	7	7	7	10	14	73	NA	UG/L		
Volatile Organics													
Acetone		1	19	3	3	3	5	120	370	NA	UG/L		
Carbon disulfide		1	24	2	2	2	5	5	100	NA	UG/L		
4-Methyl-2-pentanone		1	24	10	10	10	5	10	290	NA	UG/L		
Trichloroethene	*	1	24	2	2	2	5	5	1.6	NA	UG/L	1	

Notes:
* - Indicates chemical was identified as a COPC
SQL - Sample quantitation limit
RBC - Risk-based concentration
PG/L - picograms per liter
UG/L - micrograms per liter
NA - Not applicable or not available

Exposure Pathways

Exposure pathways for the hypothetical future site residents are dermal contact and incidental ingestion of surface soils. The exposure pathways for current site workers are the same as those for the future site residents with respect to soil. The groundwater pathway for the hypothetical future site residents is incidental ingestion of groundwater. COPCs identified for AOCs 693 and 694 were VOCs; therefore, the inhalation of volatiles pathway was not addressed for this site. Uniform exposure was assumed for all sample locations. Table 10.6.13 presents the justification for exposure pathways assessed in this HHRA.

Table 10.6.13
Exposure Pathways Summary — AOCs 693 and 694
CNC — Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Users (Site Workers)	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or nonresidential water at AOCs 693 and 694.
	Shallow groundwater, inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or nonresidential water at AOCs 693 and 694.
	Soil, incidental ingestion	No (Qualified)	Future site use is considered conservatively representative of current site use.
	Soil, dermal contact	No (Qualified)	Future site use is considered conservatively representative of current site use.
Future Land Uses			
Future Site Residents (Child and Adult), Future Site Worker	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	Yes	Shallow groundwater is not likely to be used as a source of potable or nonresidential water at AOCs 693 and 694. This pathway was addressed as a conservative measure.

Table 10.6.13
Exposure Pathways Summary — AOCs 693 and 694
CNC — Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	Volatile COPCs were not identified subsequent to risk-based screening comparisons.
	Soil, incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

Table 10.6.14 presents the EPCs for the COPCs identified in surface soil and Table 10.6.15 presents the EPCs for the COPCs identified in groundwater. Section 7 of this RFI discusses the calculation of EPCs. Except for arsenic in groundwater, EPCs were set equal to the 95% UCL. For groundwater pathways, the maximum arsenic in groundwater concentration was used as its EPC.

Quantification of Exposure

Soil

CDIs for ingestion and dermal contact with soils are shown in Tables 10.6.16 and 10.6.17, respectively.

Groundwater

CDIs for the groundwater pathway are shown in Table 10.6.18.

Table 10.6.14
Summary of Statistical Analysis
Surface Soil COPCs; AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

COPC	Natural Log Transformed n	mean	SD	H-stat	UCL (mg/kg)	MAX (mg/kg)	EPC (mg/kg)	
Inorganic								
Aluminum (Al)	27	9.689	0.761	2.202	29948	44700	29948	UCL
Antimony (Sb)	27	-0.092	1.350	2.955	5.0	28	5.0	UCL
Arsenic (As)	27	2.406	0.616	2.056	17.2	25.8	17	UCL
Chromium (Cr)	27	3.757	0.614	2.054	66.2	77.3	66	UCL
Copper (Cu)	27	3.874	1.078	2.584	148.7	1020	149	UCL
Lead (Pb)	27	4.084	0.941	2.408	144.1	481	144	UCL
Vanadium (V)	27	3.661	0.703	2.141	66.9	92.2	67	UCL
Carcinogenic PAHs								
Benzo(a)pyrene Equivalents	23	-1.400	0.692	2.165	0.43	0.54	0.43	UCL
PCBs								
Aroclor-1260	23	-3.248	1.065	2.627	0.12	0.60	0.12	UCL

NOTES:

mean Arithmetic mean of the logtransformed data
n Number of samples analyzed
SD Standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value i accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentr
NA Not applicable
EPC Exposure point concentration
UCL 95 percentile upper confidence level mean
MAX Maximum reported concentration

Table 10.6.15
Statistical Analysis of COPCs
Shallow Groundwater - AOC 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

COPC	n	Natural Log Transformed mean	SD	H-stat	UCL (mg/L)	MAX (mg/L)	EPC (ug/L)	
Inorganics								
Arsenic (As)	24	-5.171	1.696	3.549	0.084	0.067	0.067	MAX used
Cadmium (Cd)	24	-8.002	1.360	3.032	0.0020	0.019	0.0020	UCL used
Manganese (Mn)	24	-0.056	0.882	2.374	2.2	2.7	2.2	UCL used

NOTES:
mean arithmetic mean of the logtransformed data
n number of samples analyzed
SD standard deviation for a sample of data
H-stat "H" statistic from Gilbert 1987; cuboidal interpolation was used to determine the value in accordance with USEPA Supplemental Guidance to RAGS, Calculating the Concentration Term
NA not applicable
ND not determined
EPC exposure point concentration
UCL 95 percentile upper confidence level mean
MAX maximum reported concentration

Table 10.6.16
Chronic Daily Intakes
Incidental Ingestion of Surface Soil
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganic							
Aluminum (Al)	1	29948	4.1E-02	3.8E-01	4.7E-02	1.5E-02	5.2E-03
Antimony (Sb)	1	5.0	6.8E-06	6.3E-05	7.8E-06	2.4E-06	8.7E-07
Arsenic (As)	1	17	2.4E-05	2.2E-04	2.7E-05	8.4E-06	3.0E-06
Chromium (Cr)	1	66	9.1E-05	8.5E-04	1.0E-04	3.2E-05	1.2E-05
Copper (Cu)	1	149	2.0E-04	1.9E-03	2.3E-04	7.3E-05	2.6E-05
Lead (Pb)	1	144	2.0E-04	1.8E-03	2.3E-04	7.1E-05	2.5E-05
Vanadium (V)	1	67	9.2E-05	8.5E-04	1.0E-04	3.3E-05	1.2E-05
Carcinogenic PAHs							
Benzo(a)pyrene Equivalents	1	0.43	5.9E-07	5.5E-06	6.8E-07	2.1E-07	7.5E-08
PCBs							
Aroclor-1260	1	0.12	1.7E-07	1.6E-06	1.9E-07	6.1E-08	2.2E-08

NOTES:

LWA Lifetime-weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B.
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.6.17
Chronic Daily Intakes
Dermal Contact with Surface Soil
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	FI/FC *	Exposure Point Concentration (mg/kg)	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganic								
Aluminum (Al)	1	29948	0.001	1.7E-03	5.6E-03	1.1E-03	1.2E-03	4.3E-04
Antimony (Sb)	1	5.0	0.001	2.8E-07	9.2E-07	1.7E-07	2.0E-07	7.1E-08
Arsenic (As)	1	17	0.001	9.7E-07	3.2E-06	6.0E-07	6.9E-07	2.5E-07
Chromium (Cr)	1	66	0.001	3.7E-06	1.2E-05	2.3E-06	2.7E-06	9.5E-07
Copper (Cu)	1	149	0.001	8.4E-06	2.8E-05	5.2E-06	6.0E-06	2.1E-06
Lead (Pb)	1	144	0.001	8.1E-06	2.7E-05	5.1E-06	5.8E-06	2.1E-06
Vanadium (V)	1	67	0.001	3.8E-06	1.2E-05	2.4E-06	2.7E-06	9.6E-07
Carcinogenic PAHs								
Benzo(a)pyrene Equivalents	1	0.43	0.01	2.4E-07	8.0E-07	1.5E-07	1.7E-07	6.2E-08
PCBs								
Aroclor-1260	1	0.12	0.01	7.0E-08	2.3E-07	4.4E-08	5.0E-08	1.8E-08

NOTES:
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.
\- The dermal absorption factor was applied to the exposure point concentration to reflect the ability for trans-dermal migration of inorganic and organic chemicals

Table 10.6.18
Chronic Daily Intakes
Ingestion of COPCs in Shallow Groundwater
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/liter)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Inorganics						
Arsenic (As)	0.067	1.83E-03	4.28E-03	1.01E-03	6.55E-04	3.22E-04
Cadmium (Cd)	0.0020	5.46E-05	1.27E-04	3.00E-05	1.95E-05	9.60E-06
Manganese (Mn)	2.2	5.92E-02	1.38E-01	3.26E-02	2.11E-02	1.04E-02

NOTES:
LWA Lifetime-weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake

10.6.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.6.19 presents toxicological information specific to each COPC identified at AOCs 693 and 694. This information was used to quantify risk/hazard associated with soil contaminants. Each COPC's toxicology is briefly profiled in the following paragraphs.

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in water, as well as soil. This metal is water-soluble, silvery, and ductile, which suggests its usefulness in many processes. Ingesting aluminum can affect the absorption of other elements within the gastrointestinal tract and can alter intestinal function. Aluminum can potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions, which are part of the neuromuscular system controlling bowel muscles. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis) (Klaassen, et al., 1986; Dreisbach et al., 1987). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg/day. The aesthetic-based secondary MCL for drinking water is 50 to 200 μg/L.

Antimony belongs to the same periodic group as arsenic. This element is absorbed slowly through the gastrointestinal tract, which is the target of this element. Another target is the blood, where antimony concentrates. Due to frequent industrial use, the primary exposure route for antimony to the general population is food. Antimony is also a common air pollutant from industrial emissions. USEPA has not classified antimony as a carcinogen, and the oral RfD is 0.0004 mg/kg/day (Klaassen, et al., 1986). The oral RfD is based on a LOAEL of 0.35 mg/kg bw/day, an uncertainty factor of 1000, and a modifying factor of 1.

Table 10.6.19
Toxicological Reference Information
for Chemicals of Potential Concern
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

	Non-Carcinogenic Toxicity Data										*Carcinogenic Toxicity Data*					
Chemical	**Oral Reference Dose (mg/kg-day)**		**Confidence Level**	**Critical Effect**	**Uncertainty Factor Oral**	**Inhalation Reference Dose (mg/kg-day)**		**Confidence Level**	**Critical Effect**	**Uncertainty Factor Inhalation**	**Oral Slope Factor (kg-day/mg)**		**Inhalation Slope Factor (kg-day/mg)**		**Weight of Evidence**	**Tumor Type**
Aluminum	1	c	NA	NA	NA	NA		NA	NA	NA	NA		NA		NA	NA
Antimony	0.0004	a	L	whole body/blood increased mortality	1,000	NA		NA	NA	NA	NA		NA		D	NA
Arsenic	0.0003	a	M	hyperpigmentation	3	NA		NA	NA	NA	1.5	a	15.1	a	A	various
Benzo(a)pyrene Equivalents	NA		NA	NA	NA	NA		NA	NA	NA	7.3	a	6.1	d	B2	mutagen
Beryllium	0.005	a	L	microscopic organ changes	100	NA		NA	NA	NA	4.3	a	8.4	a	B2	osteosarcoma
Cadmium (food)	0.001	a	H	proteinuria	10	NA		NA	NA	NA	NA		6.3	a	B1	lung
Cadmium (water)	0.0005	a	H	proteinuria	10	NA		NA	NA	NA	NA		6.3	a	B1	lung
Chromium III	1	a	L	NA	100/10	NA		NA	NA	NA	NA		42	a	D	NA
Chromium VI	0.005	a	L	NA	500	NA		NA	NA	NA	NA		42	a	A	lung
Copper	0.0371	b	NA	NA	NA	NA		NA	NA	NA	NA		NA		D	NA
Lead	NA		NA	NA	NA	NA		NA	NA	NA	NA		NA		B2	various
Manganese (food)	0.047	a	NA	neurological effects	1	NA		NA	NA	NA	NA		NA		D	NA
Manganese (water)	0.023	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000	NA		NA		D	NA
PCB Aroclor-1260 (soil)	NA		NA	NA	NA	NA		NA	NA	NA	2	a	NA		B2	hepatocellular carcinoma
PCB Aroclor-1260 (water)	NA		NA	NA	NA	NA		NA	NA	NA	0.4	a	NA		B2	hepatocellular carcinoma
Vanadium	0.007	a	NA	unclear	100	NA		NA	NA	NA	NA		NA		D	NA

Notes:

a = Integrated Risk Information System (IRIS)
b = Health Effects Assessment Summary Tables (HEAST)
c = EPA-National Center for Environmental Assessment - Cincinnati (provisional)
d = Withdrawn from IRIS/HEAST
NA = Not applicable or not available
A = Known human carcinogen.
B1 = Probable human carcinogen based on human exposure data.
B2 = Possible human carcinogen based on laboratory animal study data.
D = Carcinogen potential not classifiable.
H = High confidence
L = Low confidence
M = Medium confidence

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.0003 mg/kg/day as the RfD for arsenic. As listed in IRIS, the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg/day)^{-1}$ SF. As listed in IRIS, the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic.

Benzo(a)pyrene equivalents include the following list of polynuclear aromatic hydrocarbons:

	TEF
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Dibenz(a,h)anthracene	1.0
Benzo(k)fluoranthene	0.01
Benzo(a)pyrene	1.0
Indeno(1,2,3-cd)pyrene	0.1
Chrysene	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established. They have no RfDs due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF of 7.3 $(mg/kg\backslash day)^{-1}$. Toxicity equivalency factors, also set by USEPA, are multipliers applied to the detected concentrations, and subsequently used to calculate excess cancer risk. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS, the basis for the benzo(a)pyrene B2 classification is animal studies. Human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

Cadmium can upset the stomach, leading to vomiting and diarrhea in acute exposure; acute inhalation of cadmium-containing dust can irritate the lungs. Chronic exposure to cadmium, either via inhalation or ingestion, has been shown to cause kidney damage (including kidney stones), emphysema, and high blood pressure. Other tissues reported to be injured by cadmium exposure in animals and humans include the lungs, testes, liver, immune system, blood, and the nervous system (Klaassen et al., 1986). An oral RfD of 0.001 (mg/kg/day) has been determined by USEPA, based on human studies (food) involving chronic exposure in which significant increased protein was found in the urine. A separate oral RfD for water has been determined by USEPA to be 0.0005 mg/kg/day. For inhalation exposure, cadmium has been classified by USEPA as a group B1, or probable human carcinogen, based on limited evidence from epidemiological studies in which excess lung cancer risk was observed in cadmium smelter workers. As listed in IRIS, the classification is based on limited evidence from occupational epidemiologic studies consistent across investigations and study populations. There is sufficient evidence of carcinogenicity in rats and mice by inhalation and intramuscular and subcutaneous injection. Seven rat and mice studies where cadmium salts (acetate, sulfate, chloride) were administered orally have shown no evidence of carcinogenic response. There is sufficient evidence of increased risk of lung cancer in rats and mice exposed to cadmium via inhalation. Seven studies in which cadmium was administered orally to rats and mice have shown no evidence of carcinogenic response following exposure via this route. As listed in IRIS, the critical effect of this chemical in water is significant proteinuria. The uncertainty factor was 10 and the modifying factor was 1.

Chromium exists in two stable, natural forms: trivalent (CrIII) and hexavalent (CrVI). Acute exposure to chromium can result in kidney damage following oral exposure or damage to the nasal mucosa and septum following inhalation exposure. Chronic inhalation exposure to hexavalent chromium has resulted in kidney and respiratory tract damage, as well as excess lung cancer in both animals and humans following occupational exposure. Only hexavalent chromium is thought to be carcinogenic by inhalation. Oral RfD values for trivalent and hexavalent chromium are 1.0 and 3E-3 mg/kg/day, respectively. For trivalent chromium, the RfD is based on liver toxicity in the rat. For the hexavalent form, the RfD is based on unspecified pathological changes observed in rat studies. In addition, hexavalent chromium is considered a group A carcinogen for inhalation exposures, and an oral SF of 41 $(mg/kg/day)^{-1}$ has been established for the hexavalent form. Vitamin supplements contain approximately 0.025 mg of chromium. As listed in IRIS, no critical effects were observed for chromium (III). The uncertainty factor was 100 and the modifying factor was 10. As listed in IRIS, no critical effects were observed for chromium (VI).

Copper is a nutritionally essential element, necessary for many of the body's enzymes. In the past, lead pipes and solder were used for residential water pipes, and resulting lead concentrations in drinking water exceeded USEPA guidelines. Copper has been used to replace water pipes in residences due to its lower toxicity to man. Short-term exposure to copper can result in anemia (the lack of iron), the breakdown of red blood cells, and liver and kidney lesions. The target organs for copper are the liver, kidney, and red blood cell. Vitamin C reduces copper uptake from the gut, and other substances can also influence copper uptake. Copper fumes can cause metal fume fever (Klaassen et al., 1986). As listed in IRIS, the D classification is based on no human data, inadequate animal data from assays of copper compounds, and equivocal mutagenicity data. The USEPA RfD is 0.0371 mg/kg\day, which is 2.6 mg/day for the average adult (70 kg). In typical vitamin supplements, 2 mg/day is the approximate dose (NRC, 1989).

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, an action level of 400 mg/kg has been proposed by USEPA Region IV: for soil protective of child residents. USEPA's OSWER has recommended a 1,000 mg/kg cleanup standard for industrial properties and its Office of Water has established a treatment technique action level of 15 μg/L. As listed in IRIS, the classification is based on sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble lead salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains, with some evidence of multiple tumor sites. Short-term studies show that lead affects gene expression. Human evidence is inadequate. An RfD and SF have not been set because of the confounding nature of lead toxicity. Lead can accumulate in bone marrow, and effects have been observed in the CNS, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate — sometimes the lead is attached to binding sites; sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight and set fat-bound lead free. This fluctuation and lack of previous lead exposure data are two of the reasons lead effects are difficult to predict (Klaassen et al., 1986).

Manganese is essential to human health, but chronic exposure (0.8 mg/kg\day) causes mental disturbances. The typical vitamin supplement dose of manganese is 2.5 mg/day. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children (Klaassen et al., 1986; Dreisbach et al., 1987). USEPA determined the RfD to be 0.14 mg/kg-day based on dietary uptake. USEPA recommended using a modifying factor of 3 when estimating intake from water. In addition, the body is roughly twice as efficient absorbing manganese in water compared to manganese in food. Because of the different uptake rates in water and food, two RfDs were used in this HHRA — one for water and one for food. The RfDs used are 0.14 and 0.023 mg/kg/day. Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia. An inhalation RfD was set to 0.0000143 mg/kg/day. According to USEPA, manganese cannot be classified as to its carcinogenicity. Therefore, the cancer class for manganese is group D. As listed in IRIS, the classification is based on studies that are inadequate to assess the carcinogenicity of manganese. As listed in IRIS, the critical effects of this chemical in water in the oral summary are CNS effects. The uncertainty factor was 1 and the recommended modifying factor of 3 was used to estimate soil and groundwater intake. The critical effects of this chemical are CNS effects. As listed in IRIS, the critical effect of this chemical in the inhalation summary is impairment of neurobehavioral function. For inhalation uptake, the uncertainty factor was 1,000 and the modifying factor was 1. The IRIS RfC is 0.00005 mg/m^3.

PCB Aroclors are a group of chlorinated hydrocarbons (such as ***Aroclors-1248, 1254, and 1260***) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and chloracne, and decreased infant birth weight in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen, et al., 1986) (Dreisbach, et al., 1987). USEPA classified PCB Aroclors as group B2 probable human carcinogens, primarily based on animal data. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. The cancer potency of PCB mixtures is determined using a tiered approach. The high risk and persistence tier uses an upper-bound slope factor of 2.0 $(mg/kg/day)^{-1}$ and is appropriate for food chain exposures, sediment and soil ingestion, dust or aerosol inhalation, and dermal exposure. The low risk and persistence tier uses an upper-bound slope factor of 0.4 (mg/kg\day)$^{-1}$ and is appropriate for ingestion of water soluble congeners and inhalation of evaporated congeners. The lowest risk and persistence tier uses an upper-bound slope factor of 0.07 (mg/kg\day)$^{-1}$ and is appropriate for PCB congener mixtures with congeners having more than four chlorines comprising less than 0.5% of the mixture.

Vanadium is not readily absorbed through the skin or oral ingestion and is a ubiquitous element. It is also a by-product of petroleum refining. Vanadium is soluble in fats and oils (Klaassen et al., 1986). Municipal water supplies contain 0.001 to 0.006 mg/L. The target organ is unclear, and the primary focus of toxicological information is inhalation of vanadium dust. Typical vitamin supplements contain approximately 0.010 mg in a daily dose. The oral RfD set by USEPA is 0.007 mg/kg/day.

10.6.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.6.20 and 10.6.21 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of and dermal contact with site surface soils, respectively.

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime-weighted average) for AOCs 693 and 694 surface soils is 5E-5. The dermal pathway ILCR is 7E-6. Arsenic and benzo(a)pyrene equivalents were the primary contributors to ILCR projections for the ingestion and dermal pathways.

Table 10.6.20
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganic							
Aluminum (Al)	1	NA	0.041	0.38	NA	0.015	NA
Antimony (Sb)	0.0004	NA	0.017	0.16	NA	0.0061	NA
Arsenic (As)	0.0003	1.5	0.078	0.73	4.0E-05	0.028	4.5E-06
Chromium (Cr)	0.003	NA	0.030	0.28	NA	0.011	NA
Copper (Cu)	0.04	NA	0.0051	0.048	NA	0.0018	NA
Lead (Pb)	NA	NA	NA	NA	NA	NA	NA
Vanadium (V)	0.007	NA	0.013	0.12	NA	0.0047	NA
Carcinogenic PAHs							
Benzo(a)pyrene Equivalents	NA	7.3	NA	NA	4.9E-06	NA	5.5E-07
PCBs							
Aroclor-1260	NA	2	NA	NA	3.9E-07	NA	4.3E-08
SUM Hazard Index/ILCR			0.2	2	5E-05	0.07	5E-06

NOTES:
NA Not available
LWA Lifetime-eighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.
ILCR Incremental Lifetime Cancer Risk

Table 10.6.21
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganic								
Aluminum (Al)	0.2	0.2	NA	0.0084	0.028	NA	0.0060	NA
Antimony (Sb)	0.2	8E-05	NA	0.0035	0.011	NA	0.0025	NA
Arsenic (As)	0.2	6E-05	7.5	0.016	0.053	4.5E-06	0.011	1.8E-06
Chromium (Cr)	0.2	0.0006	NA	0.0062	0.020	NA	0.0044	NA
Copper (Cu)	0.2	0.008	NA	0.0010	0.0034	NA	0.00075	NA
Lead (Pb)	0.2	NA	NA	NA	NA	NA	NA	NA
Vanadium (V)	0.2	0.0014	NA	0.0027	0.0089	NA	0.0019	NA
Carcinogenic PAHs								
Benzo(a)pyrene Equivalents	0.5	NA	14.6	NA	NA	2.2E-06	NA	9.0E-07
PCBs								
Aroclor-1260	0.5	NA	4	NA	NA	1.7E-07	NA	7.1E-08
SUM Hazard Index/ILCR				0.04	0.1	7E-06	0.03	3E-06

NOTES:
NA Not available
ND Not Determined due to lack of available information
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.
ILCR Incremental Lifetime Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

The ingestion HIs projected for the adult and child receptors are 0.2 and 2, respectively. The dermal pathway HIs were 0.04 for the adult resident receptor and 0.1 for the child resident receptor. Aluminum, antimony, arsenic, chromium, and vanadium were the primary contributors to HI projections for the ingestion and dermal pathways.

Hypothetical Site Workers

Site worker ILCRs are 5E-6 for the ingestion pathway and 3E-06 for the dermal contact pathway. Arsenic was the primary contributor to risk projections for the ingestion and dermal pathways.

Site worker HIs are 0.07 for the ingestion pathway and 0.03 for the dermal pathway.

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under a residential scenario based on the results of the first-round sampling event. The ingestion exposure pathway was evaluated assuming the site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately for child and adult receptors. Table 10.6.22 presents the risk and hazard for the ingestion pathway. Because no VOCs were identified as COPCs in groundwater at combined AOC 693, the inhalation pathway was not addressed at this site.

Hypothetical Site Residents

The projected ILCR for the future residential scenario is 2E-03. Arsenic was the sole contributor to ILCR projections for the groundwater ingestion pathway.

Table 10.6.22
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident LWA ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Inorganics							
Arsenic (As)	0.0003	1.5	6.1	14	1.5E-03	2.2	4.8E-04
Cadmium (Cd)	0.0005	NA	0.11	0.25	NA	0.039	NA
Manganese (Mn)	0.023	NA	2.6	6.0	NA	0.92	NA
SUM Hazard Index/ILCR			9	21	2E-03	3	5E-04

NOTES:
NA Not available
ND Not Determined due to lack of available information
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.
ILCR Incremental Lifetime excess Cancer Risk
- The one-hit equation for high carcinogenic risk levels was used for 3,3-Dimethylbenzidine resident lwa ILCR calculations

The projected hazard indices for the adult and child resident are 9 and 21, respectively. Arsenic and manganese were primary contributors to projected HIs for the groundwater ingestion pathway, and cadmium was a secondary contributor.

Hypothetical Site Workers

The projected groundwater ingestion pathway ILCR for the site worker scenario is 5E-04. Arsenic was the sole contributor to ILCR projections for the groundwater ingestion pathway.

The projected site worker HI for the groundwater ingestion pathway is 3. Arsenic and manganese were primary contributors to projected HIs for the groundwater ingestion pathway, and cadmium was a secondary contributor.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for AOCs 693 and 694 or other areas of Zone K. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

COCs Identified

Chemicals of concern were identified based on cumulative (all pathway) risk and hazard projected for this site on a medium-specific basis. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). As recommended by SCDHEC, a COC was considered to be any chemical contributing to a cumulative risk level of 1E-6 or greater and/or a cumulative hazard index above 1.0,if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative, because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used in order to provide a more comprehensive evaluation of chemicals contributing to carcinogenic risk or noncarcinogenic hazard during the remedial goal options development process. Table 10.6.23 presents the COCs identified for AOCs 693 and 694 surface soil and groundwater.

Surface Soils

Future Site Residents

Benzo(a)pyrene equivalents and arsenic were identified as soil pathway COCs based on their contribution to cumulative residential ILCR projections. Aluminum, antimony, arsenic, chromium, and vanadium were identified as soil pathway COCs based on their contribution to cumulative residential HI projections.

Future Site Workers

Benzo(a)pyrene equivalents and arsenic were identified as soil pathway COCs based on their contribution to cumulative industrial ILCR projections. No hazard-based COCs were identified for the site worker scenario.

The extent of the COCs identified in surface soil is briefly discussed below. To facilitate this discussion, residential soil RBCs and background reference concentrations were compared to each reported COC concentration. Benzo(a)pyrene equivalents were detected in 5 of 23 surface soil samples at concentrations exceeding its residential RBC (88 μg/kg). Arsenic was detected at concentrations exceeding its RBC (0.43 mg/kg) in 25 of 27 surface soil samples; however, only slightly exceeded its background reference value (23 mg/kg) in one surface soil sample (694SB005) at a concentration of 25.8 mg/kg. Aluminum was detected at concentrations exceeding its RBC (7,800 mg/kg) in 22 of 27 surface soil samples, although it only exceeded its background reference value (32,100 mg/kg) in five surface soil samples: 693SB002, 693SB003, 694SB003, 694SB005, and 694SB008. Antimony exceeded its RBC (3.1 mg/kg) in 5 of 27 surface soil samples (694SB005, 694SB009, 694SB012, 694SB014, and 694SB019), and its background reference value (2.16 mg/kg) in these five plus 694SB002 and 694SB018. The

Table 10.6.23
Summary of Risk and Hazard-based COCs
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient (HI)	Future Resident Child Hazard Quotient (HI)	Future Resident LWA ILCR	Current Site Worker Hazard Quotient	Current Site Worker ILCR	Identification of COCs
Surface Soil	Incidental	**Inorganic**						
	Ingestion	Aluminum (Al)	0.041	0.38	NA	0.015	NA	1
		Antimony (Sb)	0.017	0.16	NA	0.0061	NA	1
		Arsenic (As)	0.078	0.73	4.0E-05	0.028	4.5E-06	1 2 4
		Chromium (Cr)	0.030	0.28	NA	0.011	NA	1
		Copper (Cu)	0.0051	0.048	NA	0.0018	NA	
		Lead (Pb)	NA	NA	NA	NA	NA	
		Vanadium (V)	0.013	0.12	NA	0.0047	NA	1
		Carcinogenic PAHs						
		Benzo(a)pyrene Equivalents	NA	NA	4.9E-06	NA	5.5E-07	2 4
		PCBs						
		Aroclor-1260	NA	NA	3.9E-07	NA	4.3E-08	
	Dermal	**Inorganic**						
		Aluminum (Al)	0.0084	0.028	NA	0.0060	NA	
		Antimony (Sb)	0.0035	0.011	NA	0.0025	NA	
		Arsenic (As)	0.016	0.053	4.5E-06	0.011	1.8E-06	2 4
		Chromium (Cr)	0.0062	0.020	NA	0.0044	NA	
		Copper (Cu)	0.0010	0.0034	NA	0.00075	NA	
		Lead (Pb)	NA	NA	NA	NA	NA	
		Vanadium (V)	0.0027	0.0089	NA	0.0019	NA	
		Carcinogenic PAHs						
		Benzo(a)pyrene Equivalents	NA	NA	2.2E-06	NA	9.0E-07	2 4
		PCBs						
		Aroclor-1260	NA	NA	1.7E-07	NA	7.1E-08	
Surface Soil Pathway Sum			0.2	2	5E-05	0.09	8E-06	
Groundwater	Ingestion	**Inorganics**						
		Arsenic (As)	6.1	14	1.5E-03	2.2	4.8E-04	1 2 3 4
		Cadmium (Cd)	0.32	0.75	NA	0.12	NA	1 3
		Manganese (Mn)	3.1	7.2	NA	1.1	NA	1 3
Groundwater Pathway Sum			10	22	2E-03	3	5E-04	
Sum of All Pathways			10	24	2E-03	3	5E-04	

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
Identification of COCs
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- C[illegible]l is a COC by virtue of projected site worker noncarcinogenic hazard.
4- C[illegible]l is a COC by virtue of projected site worker ILCR.

maximum detected concentration of antimony (27.9 mg/kg at 694SB012) was approximately five times the second highest reported concentration (5.6 mg/kg at 694SB014). Chromium was detected at concentrations exceeding its RBC (23 mg/kg) in 25 of 27 surface soil samples. Chromium slightly exceeded its background reference value (69.1 mg/kg) in four surface soil samples (693SB003, 694SB005, 694SB009, and 694SB019), with a maximum detected concentration of 77.3 mg/kg. Vanadium exceeded its RBC (55 mg/kg) in 10 of 27 surface soil samples, and exceeded its background reference value (75.9 mg/kg) in only three surface soil samples (693SB002, 693SB003, and 694SB005).

First-Round Groundwater

Arsenic was identified as a groundwater COC for AOCs 693 and 694, based on its contribution to ILCR projections. Arsenic exceeded its tap-water RBC (0.045 μg/L) in 13 of 24 groundwater samples. Arsenic, cadmium, and manganese were identified as COCs based on their contribution to HI projections for the groundwater pathway at AOCs 693 and 694. Cadmium exceeded its tap-water RBC (1.8 μg/L) in three of 24 groundwater samples. Manganese exceeded its tap-water RBC (84 μg/L) in 23 of 24 groundwater samples.

10.6.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. If this area were to be used as a residential site, the surface soil conditions would likely change — the soils could be covered with landscaping soil and/or a house.

Consequently, exposure to surface soil conditions as represented by samples collected during the RFI would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

Groundwater is not currently used at AOCs 693 and 694 for potable or industrial purposes. A base-wide system provides drinking and process water to buildings throughout Zone K. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

A 95% UCL was calculated for COPCs in surface soil, and the UCL was applied as the EPC and used to estimate soil risk and hazard. Since there were fewer than 10 groundwater samples at AOCs 693 and 694, the maximum reported concentrations of each COPC identified in groundwater were used as the EPC. These approaches provide a conservative estimate of the maximum likely contaminant concentrations in soil and groundwater, and would tend to overestimate risk and hazard.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

A conservative screening process was used to identify COPCs for AOCs 693 and 694. The potential for eliminating CPSSs with the potential for cumulative HI greater than 1 was addressed for noncarcinogens through the use of RBCs that were reduced one order of magnitude. For carcinogens, the RBCs are based on a conservative target risk of 1E-06. Combining conservative RBCs with maximum detected concentrations minimizes the likelihood of a significant contribution to risk/hazard based on eliminated CPSSs. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration within 10% of its RBC.

Lead was identified as a COPC for surface soil at AOCs 693 and 694. Lead exceeded its residential screening value (400 mg/kg) in only one of 27 surface soil samples (694SB009) with a reported concentration of 481 mg/kg. The mean lead concentration for AOCs 693 and 694 is 84.2 mg/kg. Because the site is relatively large in area (approximately 3.5 acres), a mean concentration was calculated incorporating the four lead concentrations nearest to, and including, the maximum detected concentration (694SB008, 694SB009, 694SB004, and 694SB011). The mean lead concentration for the area immediately surrounding the maximum reported concentration is 175 mg/kg, indicating that lead contamination is not widespread throughout AOCs 693 and 694, and it is not expected to pose a threat to human health via the evaluated pathways.

Groundwater

The same conservative screening process used for soil is also used for groundwater; however, no background reference values have been determined for inorganics at Clouter Island. Subsequent sampling rounds produced similar data to first-round samples, indicating that samples collected in the first-round are representative of current site conditions. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration within 10% of its RBC.

Groundwater is not currently used as a potable water source at AOCs 693 and 694, nor is it used at CNC or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. It is probable that the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source if residences were constructed onsite and an unfiltered well were installed.

10.6.6.7 Risk Summary

The risk and hazard posed by contaminants at AOCs 693 and 694 were assessed for future site workers and future site residents under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. For groundwater the ingestion pathway was assessed. Table 10.6.24 summarizes the risk for each pathway/receptor group evaluated for AOCs 693 and 694.

Soil — Residential Scenario

Residential soil pathway COCs identified for AOCs 693 and 694 are aluminum, antimony, arsenic, benzo(a)pyrene equivalents, chromium, and vanadium. Figure 10.6.13 illustrates point risk estimates for AOCs 693 and 694 based on soil exposure pathways under a future residential scenario. Table 10.6.25 summarizes the risk and hazard contribution of each COPC at each sample location. This point risk map is based on the unlikely assumption that a potential future site resident would be chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of uniform exposure to the soil conditions of the entire site (or exposure unit area) rather than specific points. Risk maps supplemented by the tables help the reader visualize how chemicals driving risk estimates are spatially distributed across the site.

Arsenic is the primary contributor to risk estimates exceeding 1E-06 at 25 of 27 surface soil sample locations. Benzo(a)pyrene equivalents were a secondary contributor to risk estimates

Table 10.6.24
Summary of Risk and Hazard
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.2	2	5E-05	0.07	5E-06
	Dermal Contact	0.04	0.1	7E-06	0.03	3E-06
Sum of Soil Pathways		0.2	2	5E-05	0.09	8E-06
Groundwater	Ingestion	10	22	2E-03	NA	NA
Sum of Groundwater Pathways		10	22	2E-03	3	5E-04
Sum of All Pathways		10	24	2E-03	3	5E-04

Notes:
ILCR Indicates incremental lifetime cancer risk
HI Indicates hazard index

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
693	B001	Aluminum (Al)	22750	MG/KG	0.312	21.73	NA	
693	B001	Antimony (Sb)	0.58	MG/KG	0.020	1.38	NA	
693	B001	Aroclor-1260	110	UG/KG	NA		0.499	1.08
693	B001	Arsenic (As)	17.5	MG/KG	0.800	55.72	45.710	98.92
693	B001	B(a)P Equiv.	ND	UG/KG	NA		NA	
693	B001	Chromium (Cr)	57.1	MG/KG	0.157	10.91	NA	
693	B001	Copper (Cu)	38.4	MG/KG	0.013	0.92	NA	
693	B001	Lead (Pb)	47.4	MG/KG	NA		NA	
693	B001	Vanadium (V)	68.5	MG/KG	0.134	9.35	NA	
		Total			1.436		46.209	
693	B002	Aluminum (Al)	39000	MG/KG	0.535	27.72	NA	
693	B002	Antimony (Sb)	0.74	MG/KG	0.025	1.31	NA	
693	B002	Aroclor-1260	40	UG/KG	NA		0.181	0.32
693	B002	Arsenic (As)	21.9	MG/KG	1.001	51.89	57.203	99.68
693	B002	B(a)P Equiv.	ND	UG/KG	NA		NA	
693	B002	Chromium (Cr)	67.2	MG/KG	0.184	9.55	NA	
693	B002	Copper (Cu)	34.4	MG/KG	0.012	0.61	NA	
693	B002	Lead (Pb)	36.3	MG/KG	NA		NA	
693	B002	Vanadium (V)	87.8	MG/KG	0.172	8.92	NA	
		Total			1.929		57.384	
693	B003	Aluminum (Al)	39100	MG/KG	0.536	30.79	NA	
693	B003	Antimony (Sb)	ND	MG/KG	NA		NA	
693	B003	Aroclor-1260	52	UG/KG	NA		0.236	0.50
693	B003	Arsenic (As)	17.9	MG/KG	0.818	46.98	46.755	99.50
693	B003	B(a)P Equiv.	ND	UG/KG	NA		NA	
693	B003	Chromium (Cr)	75	MG/KG	0.206	11.81	NA	
693	B003	Copper (Cu)	36.1	MG/KG	0.012	0.71	NA	
693	B003	Lead (Pb)	39.3	MG/KG	NA		NA	
693	B003	Vanadium (V)	86.3	MG/KG	0.169	9.71	NA	
		Total			1.741		46.991	

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
693	B004	Aluminum (Al)	11700	MG/KG	0.160	19.16	NA	
693	B004	Antimony (Sb)	ND	MG/KG	NA		NA	
693	B004	Aroclor-1260	48	UG/KG	NA		0.218	0.74
693	B004	Arsenic (As)	11.2	MG/KG	0.512	61.14	29.254	99.26
693	B004	B(a)P Equiv.	ND	UG/KG	NA		NA	
693	B004	Chromium (Cr)	29.4	MG/KG	0.081	9.63	NA	
693	B004	Copper (Cu)	21.5	MG/KG	0.007	0.88	NA	
693	B004	Lead (Pb)	33	MG/KG	NA		NA	
693	B004	Vanadium (V)	39.3	MG/KG	0.077	9.19	NA	
		Total			0.837		29.472	
694	B001	Aluminum (Al)	1370	MG/KG	0.019	30.77	NA	
694	B001	Antimony (Sb)	0.56	MG/KG	0.019	31.45	NA	
694	B001	Aroclor-1260	ND	UG/KG	NA		NA	
694	B001	Arsenic (As)	ND	MG/KG	NA		NA	
694	B001	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B001	Chromium (Cr)	4.8	MG/KG	0.013	21.56	NA	
694	B001	Copper (Cu)	4.3	MG/KG	0.001	2.41	NA	
694	B001	Lead (Pb)	5.3	MG/KG	NA		NA	
694	B001	Vanadium (V)	4.3	MG/KG	0.008	13.80	NA	
		Total			0.061		0.000	
694	B002	Aluminum (Al)	30100	MG/KG	0.413	28.99	NA	
694	B002	Antimony (Sb)	2.5	MG/KG	0.086	6.02	NA	
694	B002	Aroclor-1260	ND	UG/KG	NA		NA	
694	B002	Arsenic (As)	14.7	MG/KG	0.672	47.20	38.396	100.00
694	B002	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B002	Chromium (Cr)	51.9	MG/KG	0.142	10.00	NA	
694	B002	Copper (Cu)	32.1	MG/KG	0.011	0.77	NA	
694	B002	Lead (Pb)	48.9	MG/KG	NA		NA	
694	B002	Vanadium (V)	51	MG/KG	0.100	7.02	NA	
		Total			1.424		38.396	

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
694	B003	Aluminum (Al)	33100	MG/KG	0.454	29.40	NA	
694	B003	Antimony (Sb)	0.64	MG/KG	0.022	1.42	NA	
694	B003	Aroclor-1260	ND	UG/KG	NA		NA	
694	B003	Arsenic (As)	16.3	MG/KG	0.745	48.26	42.576	95.54
694	B003	B(a)P Equiv.	120.13	UG/KG	NA		1.989	4.46
694	B003	Chromium (Cr)	63	MG/KG	0.173	11.19	NA	
694	B003	Copper (Cu)	33.8	MG/KG	0.012	0.75	NA	
694	B003	Lead (Pb)	49.6	MG/KG	NA		NA	
694	B003	Vanadium (V)	70.7	MG/KG	0.138	8.97	NA	
		Total			1.544		44.565	
694	B004	Aluminum (Al)	28200	MG/KG	0.387	30.31	NA	
694	B004	Antimony (Sb)	1	MG/KG	0.034	2.69	NA	
694	B004	Aroclor-1260	ND	UG/KG	NA		NA	
694	B004	Arsenic (As)	12.5	MG/KG	0.571	44.78	32.650	100.00
694	B004	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B004	Chromium (Cr)	53.2	MG/KG	0.146	11.44	NA	
694	B004	Copper (Cu)	82.6	MG/KG	0.028	2.22	NA	
694	B004	Lead (Pb)	65.3	MG/KG	NA		NA	
694	B004	Vanadium (V)	55.8	MG/KG	0.109	8.57	NA	
		Total			1.276		32.650	
694	B005	Aluminum (Al)	44700	MG/KG	0.613	26.52	NA	
694	B005	Antimony (Sb)	3.3	MG/KG	0.113	4.89	NA	
694	B005	Aroclor-1260	50	UG/KG	NA		0.227	0.34
694	B005	Arsenic (As)	25.8	MG/KG	1.179	51.02	67.390	99.66
694	B005	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B005	Chromium (Cr)	77.3	MG/KG	0.212	9.17	NA	
694	B005	Copper (Cu)	39.6	MG/KG	0.014	0.59	NA	
694	B005	Lead (Pb)	46	MG/KG	NA		NA	
694	B005	Vanadium (V)	92.2	MG/KG	0.181	7.81	NA	
		Total			2.312		67.616	

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
694	B006	Aluminum (Al)	5160	MG/KG	0.071	47.16	NA	
694	B006	Antimony (Sb)	ND	MG/KG	NA		NA	
694	B006	Aroclor-1260	26	UG/KG	NA		0.118	100.00
694	B006	Arsenic (As)	ND	MG/KG	NA		NA	
694	B006	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B006	Chromium (Cr)	16.7	MG/KG	0.046	30.53	NA	
694	B006	Copper (Cu)	30.2	MG/KG	0.010	6.90	NA	
694	B006	Lead (Pb)	34.7	MG/KG	NA		NA	
694	B006	Vanadium (V)	11.8	MG/KG	0.023	15.41	NA	
		Total			0.150		0.118	
694	B007	Aluminum (Al)	17100	MG/KG	0.234	23.42	NA	
694	B007	Antimony (Sb)	0.81	MG/KG	0.028	2.77	NA	
694	B007	Aroclor-1260	170	UG/KG	NA		0.771	2.46
694	B007	Arsenic (As)	11.7	MG/KG	0.535	53.42	30.560	97.54
694	B007	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B007	Chromium (Cr)	38.1	MG/KG	0.104	10.44	NA	
694	B007	Copper (Cu)	55.2	MG/KG	0.019	1.89	NA	
694	B007	Lead (Pb)	72.4	MG/KG	NA		NA	
694	B007	Vanadium (V)	41.2	MG/KG	0.081	8.06	NA	
		Total			1.001		31.332	
694	B008	Aluminum (Al)	33200	MG/KG	0.455	29.52	NA	
694	B008	Antimony (Sb)	0.67	MG/KG	0.023	1.49	NA	
694	B008	Aroclor-1260	ND	UG/KG	NA		NA	
694	B008	Arsenic (As)	16.5	MG/KG	0.754	48.90	43.098	100.00
694	B008	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B008	Chromium (Cr)	59.7	MG/KG	0.164	10.62	NA	
694	B008	Copper (Cu)	48.6	MG/KG	0.017	1.08	NA	
694	B008	Lead (Pb)	53.1	MG/KG	NA		NA	
694	B008	Vanadium (V)	66.1	MG/KG	0.129	8.40	NA	
		Total			1.542		43.098	

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
694	B009	Aluminum (Al)	14100	MG/KG	0.193	16.16	NA	
694	B009	Antimony (Sb)	3.7	MG/KG	0.127	10.60	NA	
694	B009	Aroclor-1260	100	UG/KG	NA		0.454	1.33
694	B009	Arsenic (As)	10.6	MG/KG	0.485	40.51	27.687	81.24
694	B009	B(a)P Equiv.	358.8	UG/KG	NA		5.942	17.43
694	B009	Chromium (Cr)	69.5	MG/KG	0.191	15.94	NA	
694	B009	Copper (Cu)	260	MG/KG	0.089	7.45	NA	
694	B009	Lead (Pb)	481	MG/KG	NA		NA	
694	B009	Vanadium (V)	57	MG/KG	0.112	9.34	NA	
		Total			1.196		34.083	
694	B010	Aluminum (Al)	21400	MG/KG	0.293	19.30	NA	
694	B010	Antimony (Sb)	ND	MG/KG	NA		NA	
694	B010	Aroclor-1260	ND	UG/KG	NA		NA	
694	B010	Arsenic (As)	21.5	MG/KG	0.983	64.63	56.158	100.00
694	B010	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B010	Chromium (Cr)	48.7	MG/KG	0.134	8.78	NA	
694	B010	Copper (Cu)	11.2	MG/KG	0.004	0.25	NA	
694	B010	Lead (Pb)	18.2	MG/KG	NA		NA	
694	B010	Vanadium (V)	54.6	MG/KG	0.107	7.03	NA	
		Total			1.521		56.158	
694	B011	Aluminum (Al)	17000	MG/KG	0.233	21.74	NA	
694	B011	Antimony (Sb)	0.89	MG/KG	0.031	2.85	NA	
694	B011	Aroclor-1260	90.7	UG/KG	NA		0.412	1.29
694	B011	Arsenic (As)	12.1	MG/KG	0.553	51.57	31.605	98.71
694	B011	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B011	Chromium (Cr)	55.7	MG/KG	0.153	14.24	NA	
694	B011	Copper (Cu)	60.8	MG/KG	0.021	1.94	NA	
694	B011	Lead (Pb)	98.6	MG/KG	NA		NA	
694	B011	Vanadium (V)	41.9	MG/KG	0.082	7.65	NA	
		Total			1.072		32.017	

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
694	B012	Aluminum (Al)	7150	MG/KG	0.098	6.25	NA	
694	B012	Antimony (Sb)	27.9	MG/KG	0.956	60.96	NA	
694	B012	Aroclor-1260	65.8	UG/KG	NA		0.299	1.56
694	B012	Arsenic (As)	7.2	MG/KG	0.329	20.97	18.806	98.44
694	B012	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B012	Chromium (Cr)	43.3	MG/KG	0.119	7.57	NA	
694	B012	Copper (Cu)	77.4	MG/KG	0.027	1.69	NA	
694	B012	Lead (Pb)	105	MG/KG	NA		NA	
694	B012	Vanadium (V)	20.5	MG/KG	0.040	2.56	NA	
		Total			1.569		19.105	
694	B013	Aluminum (Al)	17900	MG/KG	0.245	19.59	NA	
694	B013	Antimony (Sb)	ND	MG/KG	NA		NA	
694	B013	Aroclor-1260	ND	UG/KG	NA		NA	
694	B013	Arsenic (As)	17.4	MG/KG	0.795	63.48	45.449	83.67
694	B013	B(a)P Equiv.	535.46	UG/KG	NA		8.867	16.33
694	B013	Chromium (Cr)	41.2	MG/KG	0.113	9.02	NA	
694	B013	Copper (Cu)	14.8	MG/KG	0.005	0.40	NA	
694	B013	Lead (Pb)	30.7	MG/KG	NA		NA	
694	B013	Vanadium (V)	48	MG/KG	0.094	7.51	NA	
		Total			1.253		54.316	
694	B014	Aluminum (Al)	6720	MG/KG	0.092	6.54	NA	
694	B014	Antimony (Sb)	5.6	MG/KG	0.192	13.63	NA	
694	B014	Aroclor-1260	596	UG/KG	NA		2.704	7.88
694	B014	Arsenic (As)	12.1	MG/KG	0.553	39.27	31.605	92.12
694	B014	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B014	Chromium (Cr)	63.9	MG/KG	0.175	12.44	NA	
694	B014	Copper (Cu)	1020	MG/KG	0.350	24.83	NA	
694	B014	Lead (Pb)	391	MG/KG	NA		NA	
694	B014	Vanadium (V)	23.7	MG/KG	0.046	3.30	NA	
		Total			1.409		34.309	

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

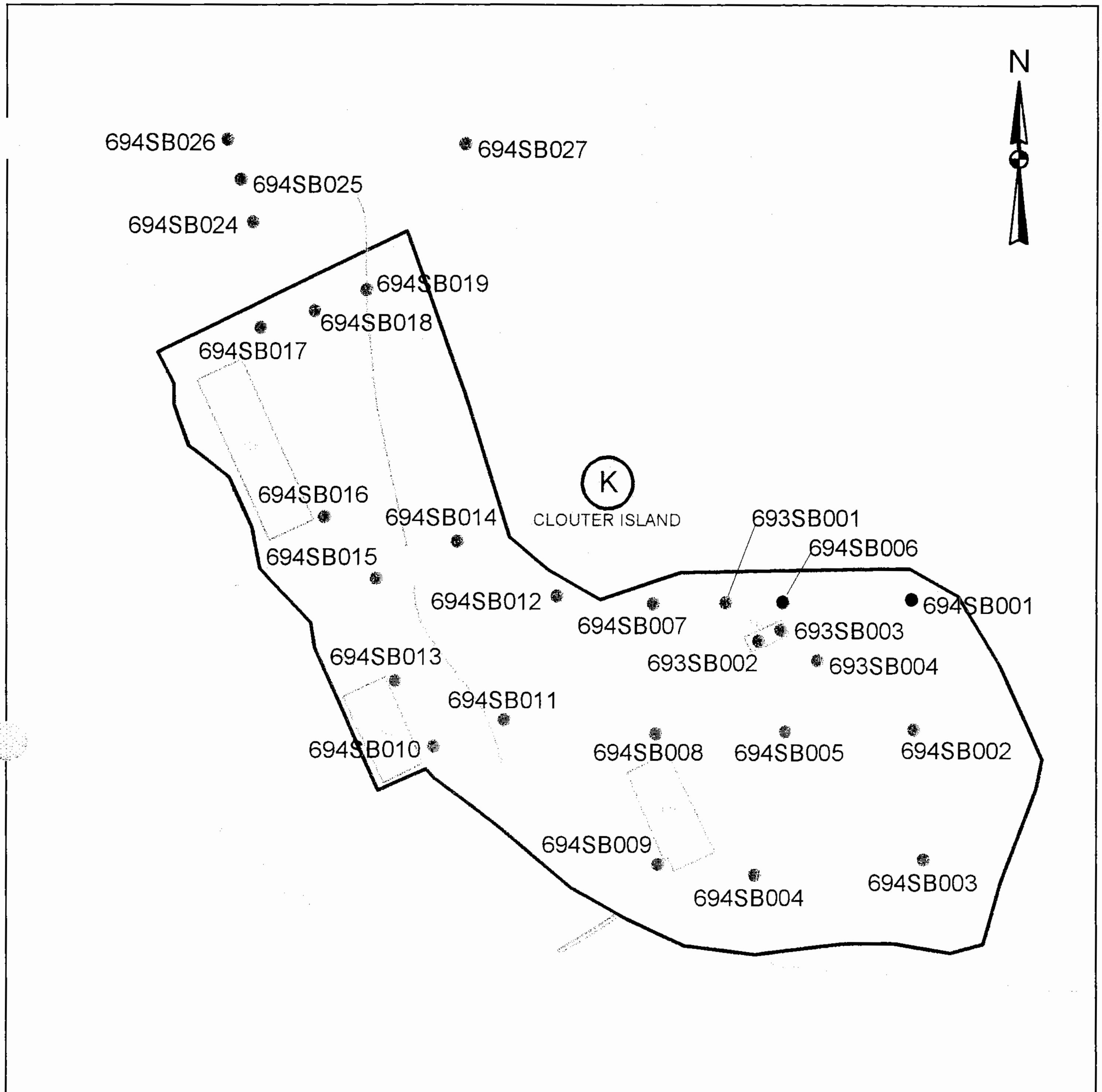
Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
694	B015	Aluminum (Al)	12400	MG/KG	0.170	24.74	NA	
694	B015	Antimony (Sb)	ND	MG/KG	NA		NA	
694	B015	Aroclor-1260	73.3	UG/KG	NA		0.333	1.57
694	B015	Arsenic (As)	8	MG/KG	0.366	53.20	20.896	98.43
694	B015	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B015	Chromium (Cr)	29	MG/KG	0.080	11.57	NA	
694	B015	Copper (Cu)	41.1	MG/KG	0.014	2.05	NA	
694	B015	Lead (Pb)	51.6	MG/KG	NA		NA	
694	B015	Vanadium (V)	29.6	MG/KG	0.058	8.44	NA	
		Total			0.687		21.229	
694	B016	Aluminum (Al)	16100	MG/KG	0.221	27.02	NA	
694	B016	Antimony (Sb)	0.83	MG/KG	0.028	3.48	NA	
694	B016	Aroclor-1260	71.9	UG/KG	NA		0.326	1.33
694	B016	Arsenic (As)	8.6	MG/KG	0.393	48.12	22.463	91.59
694	B016	B(a)P Equiv.	104.799	UG/KG	NA		1.736	7.08
694	B016	Chromium (Cr)	33.2	MG/KG	0.091	11.15	NA	
694	B016	Copper (Cu)	50	MG/KG	0.017	2.10	NA	
694	B016	Lead (Pb)	81.3	MG/KG	NA		NA	
694	B016	Vanadium (V)	33.9	MG/KG	0.066	8.13	NA	
		Total			0.817		24.525	
694	B017	Aluminum (Al)	12300	MG/KG	0.169	20.61	NA	
694	B017	Antimony (Sb)	1.1	MG/KG	0.038	4.61	NA	
694	B017	Aroclor-1260	74.8	UG/KG	NA		0.339	1.32
694	B017	Arsenic (As)	9.7	MG/KG	0.443	54.17	25.336	98.68
694	B017	B(a)P Equiv.	ND	UG/KG	NA		NA	
694	B017	Chromium (Cr)	30.6	MG/KG	0.084	10.25	NA	
694	B017	Copper (Cu)	57.7	MG/KG	0.020	2.42	NA	
694	B017	Lead (Pb)	50.9	MG/KG	NA		NA	
694	B017	Vanadium (V)	33.2	MG/KG	0.065	7.95	NA	
		Total			0.818		25.676	

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
694	B018	Aluminum (Al)	12300	MG/KG	0.169	22.11	NA	
694	B018	Antimony (Sb)	2.2	MG/KG	0.075	9.89	NA	
694	B018	Aroclor-1260	ND	UG/KG	NA		NA	
694	B018	Arsenic (As)	7.4	MG/KG	0.338	44.34	19.329	77.62
694	B018	B(a)P Equiv.	336.57	UG/KG	NA		5.574	22.38
694	B018	Chromium (Cr)	34.4	MG/KG	0.094	12.37	NA	
694	B018	Copper (Cu)	99.7	MG/KG	0.034	4.48	NA	
694	B018	Lead (Pb)	133	MG/KG	NA		NA	
694	B018	Vanadium (V)	26.5	MG/KG	0.052	6.81	NA	
		Total			0.763		24.903	
694	B019	Aluminum (Al)	6510	MG/KG	0.089	9.04	NA	
694	B019	Antimony (Sb)	5.1	MG/KG	0.175	17.71	NA	
694	B019	Aroclor-1260	ND	UG/KG	NA		NA	
694	B019	Arsenic (As)	9	MG/KG	0.411	41.67	23.508	98.69
694	B019	B(a)P Equiv.	18.8	UG/KG	NA		0.311	1.31
694	B019	Chromium (Cr)	75	MG/KG	0.206	20.84	NA	
694	B019	Copper (Cu)	160	MG/KG	0.055	5.56	NA	
694	B019	Lead (Pb)	177	MG/KG	NA		NA	
694	B019	Vanadium (V)	26.1	MG/KG	0.051	5.18	NA	
		Total			0.987		23.819	
694	B024	Aluminum (Al)	24200	MG/KG	0.332	24.22	NA	
694	B024	Antimony (Sb)	ND	MG/KG	NA		NA	
694	B024	Arsenic (As)	13.8	MG/KG	0.631	46.03	36.046	100.00
694	B024	Chromium (Cr)	60.5	MG/KG	0.276	20.16	NA	
694	B024	Copper (Cu)	32.8	MG/KG	0.011	0.81	NA	
694	B024	Lead (Pb)	35.6	MG/KG	NA		NA	
694	B024	Vanadium (V)	61.4	MG/KG	0.120	8.78	NA	
		Total			1.370		36.046	
694	B025	Aluminum (Al)	17000	MG/KG	0.233	22.06	NA	
694	B025	Antimony (Sb)	ND	MG/KG	NA		NA	
694	B025	Arsenic (As)	12.4	MG/KG	0.567	53.63	32.389	100.00
694	B025	Chromium (Cr)	35.8	MG/KG	0.163	15.47	NA	
694	B025	Copper (Cu)	28.8	MG/KG	0.010	0.93	NA	
694	B025	Lead (Pb)	28.9	MG/KG	NA		NA	
694	B025	Vanadium (V)	42.7	MG/KG	0.084	7.92	NA	
		Total			1.057		32.389	
694	B026	Aluminum (Al)	20100	MG/KG	0.276	23.67	NA	
694	B026	Antimony (Sb)	ND	MG/KG	NA		NA	
694	B026	Arsenic (As)	13.5	MG/KG	0.617	52.99	35.262	100.00
694	B026	Chromium (Cr)	38.6	MG/KG	0.176	15.14	NA	

Table 10.6.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
694	B026	Copper (Cu)	26.7	MG/KG	0.009	0.78	NA	
694	B026	Lead (Pb)	31.4	MG/KG	NA		NA	
694	B026	Vanadium (V)	44.1	MG/KG	0.086	7.42	NA	
		Total			1.164		35.262	
694	B027	Aluminum (Al)	28100	MG/KG	0.385	24.96	NA	
694	B027	Antimony (Sb)	ND	MG/KG	NA		NA	
694	B027	Arsenic (As)	17.2	MG/KG	0.786	50.93	44.926	100.00
694	B027	Chromium (Cr)	51.3	MG/KG	0.234	15.18	NA	
694	B027	Copper (Cu)	29.8	MG/KG	0.010	0.66	NA	
694	B027	Lead (Pb)	27.6	MG/KG	NA		NA	
694	B027	Vanadium (V)	65.2	MG/KG	0.128	8.27	NA	
		Total			1.544		44.926	



LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

100 0 100 200 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.6.13
AOCs 693 and 694

POINT RISK ESTIMATES FOR
SURFACE SOIL
RESIDENTIAL SCENARIO

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associated with six surface soil sample locations: 694SB003, 694SB009, 694SB013, 694SB016, 694SB018, and 694SB019. Risk estimates ranged from 7E-07 (694SB001) to 8E-05 (694SB005).

Figure 10.6.14 illustrates point estimates for hazard at AOCs 693 and 694 based on soil exposure pathways under a future residential scenario. Aluminum and arsenic were primary contributors to hazard estimates exceeding unity at AOCs 693 and 694. Secondary contributors were antimony, chromium, copper, and vanadium. Hazard index estimates ranged from 0.06 (694SB001) to 2.3 (694SB005).

Soil — Site Worker Scenario

Arsenic and benzo(a)pyrene equivalents were identified as COCs for the industrial surface soil pathway. Figure 10.6.15 illustrates point risk estimates for AOCs 693 and 694 based on soil exposure pathways under a future industrial scenario. Table 10.6.26 summarizes the risk and hazard contribution of each COC at each sample location. Although the cumulative industrial ILCR estimate for benzo(a)pyrene equivalents is 1E-06, the maximum reported concentration of benzo(a)pyrene equivalents (535.46 μg/kg) was less than its industrial RBC (780 μg/kg). Therefore, benzo(a)pyrene equivalents were considered to be borderline COCs for the industrial scenario, and were not included in point risk tables or figures.

Arsenic was the primary contributor to risk estimates exceeding 1E-06 for the industrial scenario at AOCs 693 and 694. Risk estimates ranged from 1E-07 (694SB001) to 1E-05 (694SB005). Hazard estimates ranged from 0.00001 (694SB005) to 0.06 (694SB005).

Groundwater — Residential Scenario

Arsenic, cadmium, and manganese were identified as groundwater pathway COCs. Figure 10.6.16 illustrates point risk estimates for AOCs 693 and 694 based on groundwater exposure pathways under a future residential scenario. As shown in Table 10.6.27, arsenic was the sole contributor

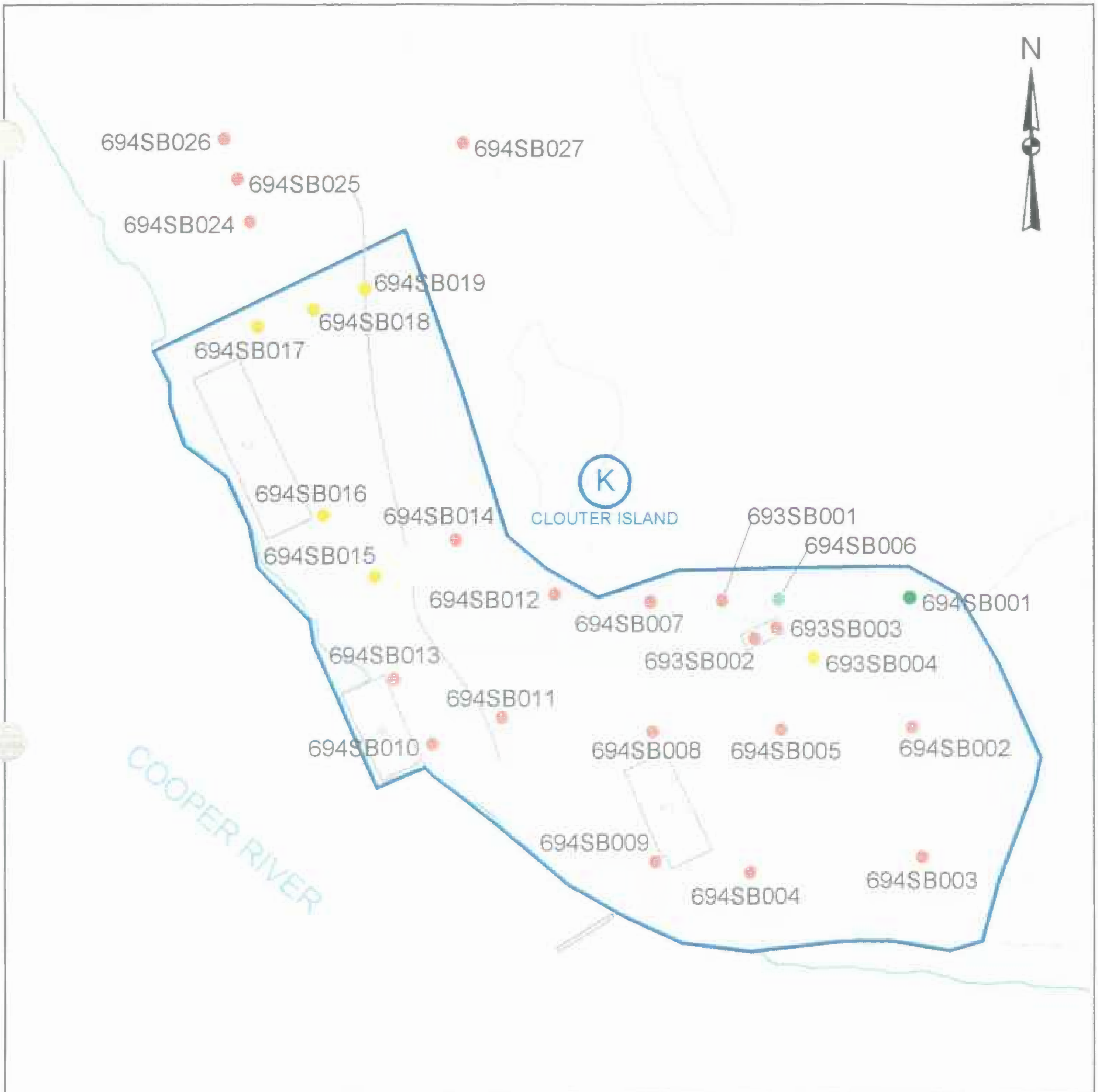
Table 10.6.26
Point Estimates of Risk and Hazard - Surface Soil Pathways
Industrial Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
693	B001	Arsenic (As)	17.5	MG/KG	0.040	6.5
693	B002	Arsenic (As)	21.9	MG/KG	0.050	8.1
693	B003	Arsenic (As)	17.9	MG/KG	0.041	6.6
693	B004	Arsenic (As)	11.2	MG/KG	0.026	4.1
694	B001	Arsenic (As)	ND	MG/KG	NA	NA
694	B002	Arsenic (As)	14.7	MG/KG	0.034	5.4
694	B003	Arsenic (As)	16.3	MG/KG	0.037	6.0
694	B004	Arsenic (As)	12.5	MG/KG	0.029	4.6
694	B005	Arsenic (As)	25.8	MG/KG	0.059	9.5
694	B006	Arsenic (As)	ND	MG/KG	NA	NA

Table 10.6.26
Point Estimates of Risk and Hazard - Surface Soil Pathways
Industrial Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	Risk (E-06)
694	B007	Arsenic (As)	11.7	MG/KG	0.027	4.3
694	B008	Arsenic (As)	16.5	MG/KG	0.038	6.1
694	B009	Arsenic (As)	10.6	MG/KG	0.024	3.9
694	B010	Arsenic (As)	21.5	MG/KG	0.049	7.9
694	B011	Arsenic (As)	12.1	MG/KG	0.028	4.5
694	B012	Arsenic (As)	7.2	MG/KG	0.017	2.7
694	B013	Arsenic (As)	17.4	MG/KG	0.040	6.4
694	B014	Arsenic (As)	12.1	MG/KG	0.028	4.5
694	B015	Arsenic (As)	8	MG/KG	0.018	3.0
694	B016	Arsenic (As)	8.6	MG/KG	0.020	3.2

Table 10.6.26 1



LEGEND

- NO COPCs
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

100 0 100 200 Feet

ZONE K - RCRA
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NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.6.14
AOCs 693 and 694

POINT HAZARD ESTIMATES FOR
SURFACE SOIL
RESIDENTIAL SCENARIO

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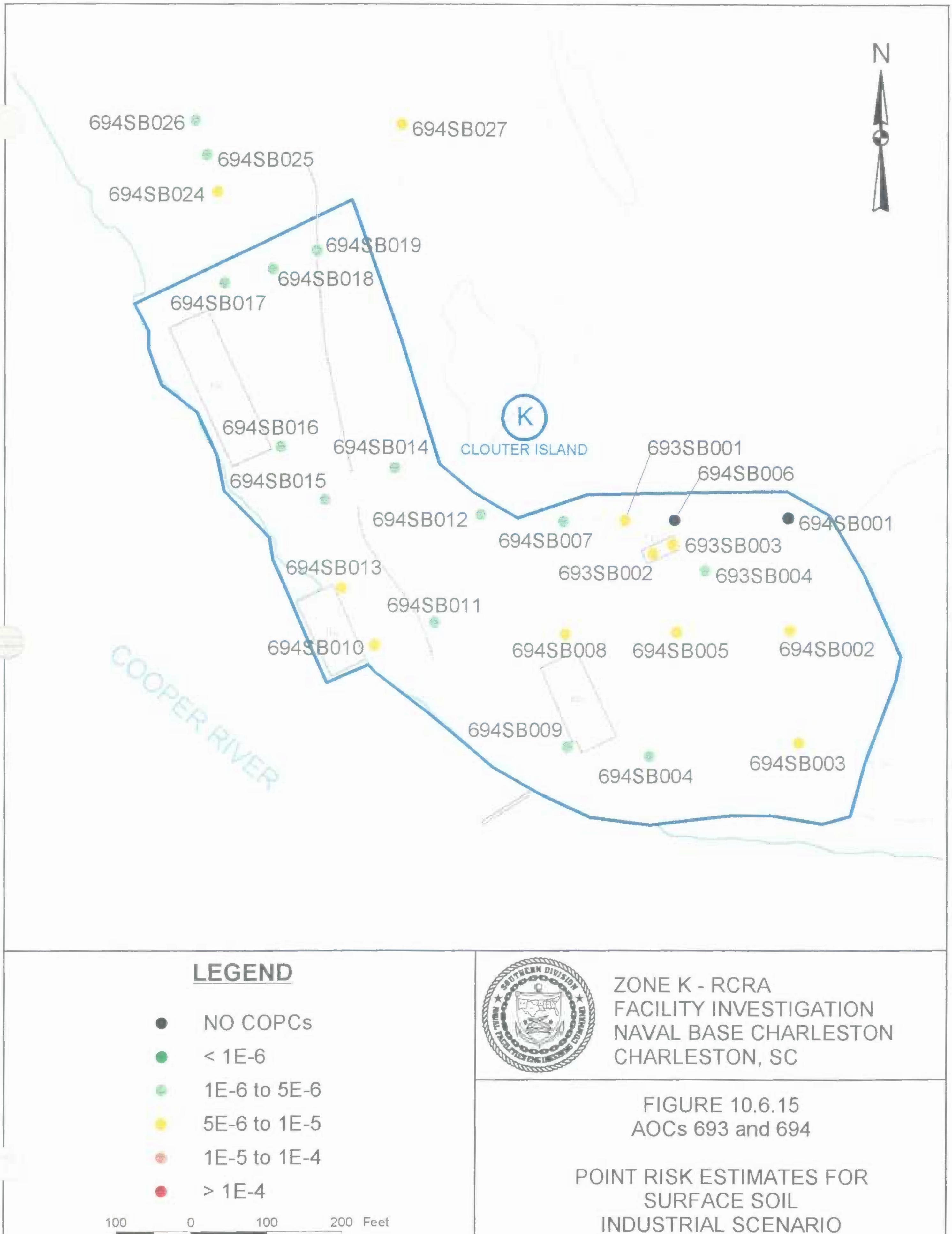

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.6.15
AOCs 693 and 694

POINT RISK ESTIMATES FOR
SURFACE SOIL
INDUSTRIAL SCENARIO

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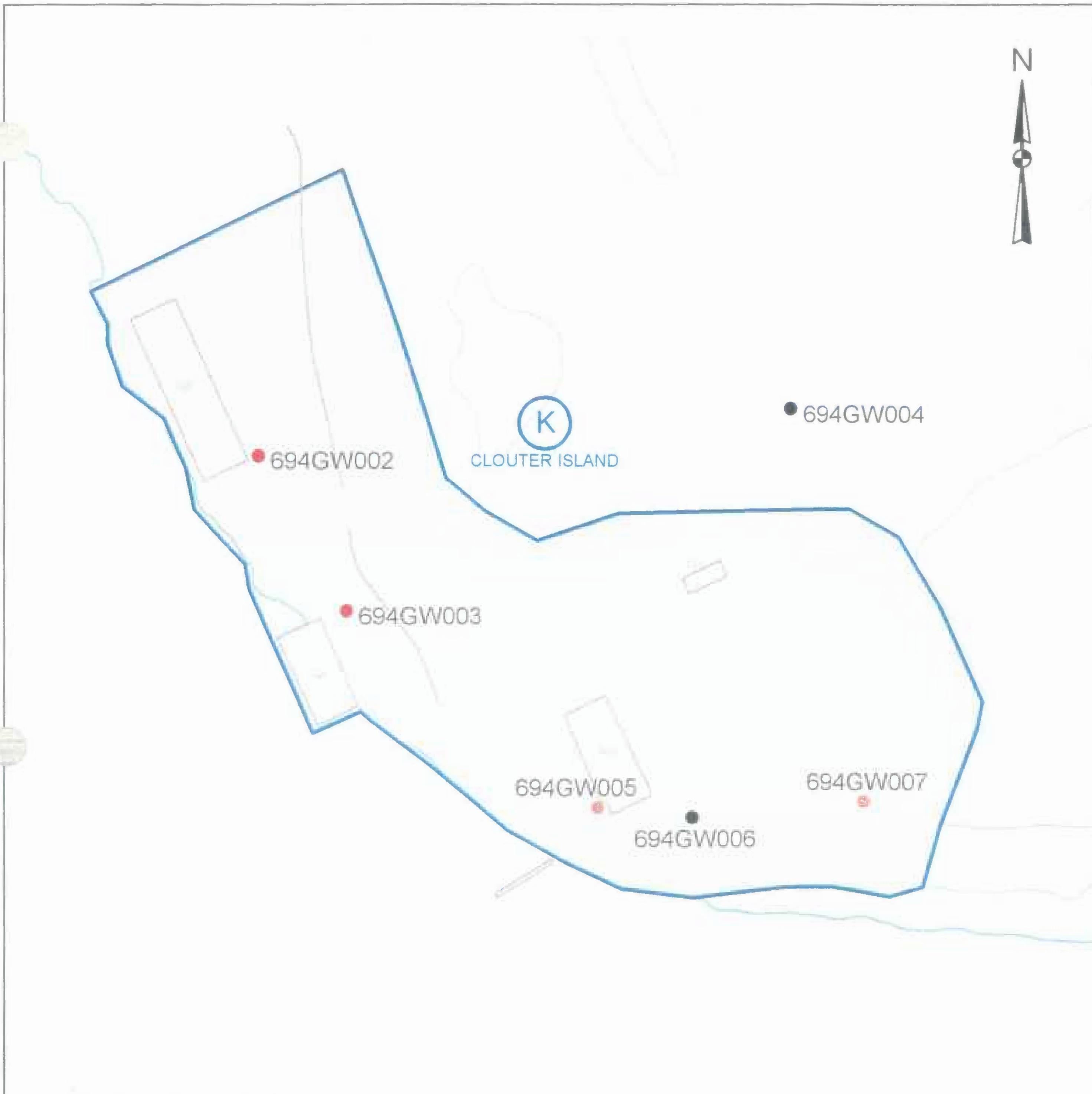

LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

100 0 100 200 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
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FIGURE 10.6.16
AOCs 693 and 694

POINT RISK ESTIMATES FOR
GROUNDWATER
RESIDENTIAL SCENARIO

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Table 10.6.27
Point Estimates of Risk and Hazard - Groundwater Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Round	Parameter	Concentration	Units	Hazard Inde	%HI	Risk (E-06)	%Risk
694	G002	01	Arsenic (As)	66.9	UG/L	14.3	66.36	1492	100.00
			Manganese (Mn)	2600	UG/L	7.2	33.64	NA	
			Total			21.5		1492	
694	G002	02	Arsenic (As)	63.3	UG/L	13.5	80.58	1412	100.00
			Cadmium (Cd)	0.56	UG/L	0.1		NA	
			Manganese (Mn)	2670	UG/L	3.2	18.99	NA	
			Total			16.7		1412	
694	G002	03	Arsenic (As)	57.7	UG/L	12.3	83.64	1287	100.00
			Manganese (Mn)	2020	UG/L	2.4	16.36	NA	
			Total			14.7		1287	
694	G002	04	Arsenic (As)	51.2	UG/L	10.9	83.36	1142	100.00
			Manganese (Mn)	1830	UG/L	2.2	16.64	NA	
			Total			13.1		1142	
694	G003	01	Arsenic (As)	43.2	UG/L	9.2	67.84	964	100.00
			Manganese (Mn)	1570	UG/L	4.4	32.16	NA	
			Total			13.6		964	
694	G003	02	Arsenic (As)	48.8	UG/L	10.4	84.76	1089	100.00
			Manganese (Mn)	1570	UG/L	1.9	15.24	NA	
			Total			12.3		1089	
694	G003	03	Arsenic (As)	38.9	UG/L	8.3	81.60	868	100.00
			Manganese (Mn)	1570	UG/L	1.9	18.40	NA	
			Total			10.2		868	
694	G003	04	Arsenic (As)	47.6	UG/L	10.1	84.44	1062	100.00
			Manganese (Mn)	1570	UG/L	1.9	15.56	NA	
			Total			12.0		1062	
694	G004	01	Cadmium (Cd)	2.1	UG/L	0.27	56.00	NA	
			Manganese (Mn)	75.9	UG/L	0.21	44.00	NA	
			Total			0.48		NA	
694	G004	02	Cadmium (Cd)	0.4	UG/L	0.05	4.69	NA	
			Manganese (Mn)	873	UG/L	1.04	95.31	NA	
			Total			1.09		NA	
694	G004	03	Manganese (Mn)	1250	UG/L	1.49		NA	
694	G004	04	Manganese (Mn)	1200	UG/L	1.43		NA	
694	G005	01	Manganese (Mn)	254	UG/L	0.71		NA	
694	G005	02	Arsenic (As)	3.2	UG/L	0.68	67.96	71.4	100.00
			Manganese (Mn)	270	UG/L	0.32	32.04	NA	
			Total			1.00		71.4	
694	G005	03	Manganese (Mn)	307	UG/L	0.37		NA	
694	G005	04	Arsenic (As)	2.4	UG/L	0.51	66.34	53.5	100.00
			Manganese (Mn)	218	UG/L	0.26	33.66	NA	
			Total			0.77		53.5	

Table 10.6.27
Point Estimates of Risk and Hazard - Groundwater Pathways
Residential Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Round	Parameter	Concentration	Units	Hazard Inde	%HI	Risk (E-06)	%Risk
694	G006	01	Arsenic (As)	3.4	UG/L	0.72	12.17	75.9	100.00
			Cadmium (Cd)	5.9	UG/L	0.75	12.67	NA	
			Manganese (Mn)	1610	UG/L	4.47	75.16	NA	
			Total			5.95		75.9	
694	G006	02	Manganese (Mn)	1660	UG/L	1.98		NA	
694	G006	03	Manganese (Mn)	1360	UG/L	1.62		NA	
694	G006	04	Manganese (Mn)	936	UG/L	1.11		NA	
694	G007	01	Manganese (Mn)	1330	UG/L	3.70	100.00	NA	
694	G007	02	Arsenic (As)	3	UG/L	0.64	13.48	66.9	100.00
			Cadmium (Cd)	19.3	UG/L	2.47	52.02	NA	
			Manganese (Mn)	1375	UG/L	1.64	34.51	NA	
			Total			4.74		66.9	
694	G007	03	Cadmium (Cd)	0.6	UG/L	0.08	6.33	NA	
			Manganese (Mn)	953.5	UG/L	1.14	93.67	NA	
			Total			1.21		NA	
694	G007	04	Arsenic (As)	2.5	UG/L	0.53	29.01	55.8	100.00
			Manganese (Mn)	1095	UG/L	1.30	70.99	NA	
			Total			1.84		55.8	

to ILCR projections at AOCs 693 and 694. Risk estimates ranged from 5E-05 (NBCK694005 fourth round) to 1E-03 (NBCK694002 first round).

Figure 10.6.17 illustrates point estimates for hazard at AOCs 693 and 694 based on groundwater exposure pathways under a future residential scenario. Arsenic, cadmium, and manganese were all contributors to hazard projections at AOCs 693 and 694 (Table 10.6.27). Hazard estimates ranged from 0.4 (NBCK694005 third round) to 22 (NBCK694002 first round).

Groundwater — Site Worker Scenario

Arsenic, cadmium, and manganese were identified as groundwater pathway COCs. Figure 10.6.18 illustrates point risk estimates for AOCs 693 and 694 based on groundwater exposure pathways under a site worker scenario. As shown in Table 10.6.28, arsenic was the sole contributor to ILCR projections at AOCs 693 and 694. Risk estimates ranged from 3E-05 (NBCK694005 fourth-round) to 7E-04 (NBCK694002 first-round). Figure 10.6.19 illustrates point estimates for hazard at AOCs 693 and 694 based on groundwater exposure pathways under a site worker scenario. Arsenic, cadmium, and manganese were all contributors to hazard projections at AOCs 693 and 694 (Table 10.6.28). Hazard estimates ranged from 0.2 (NBCK694004 first-round) to 7 (NBCK694002 first-round).

10.6.6.8 Remedial Goal Options

Soil

RGOs for carcinogens were based on the lifetime-weighted average site resident or site worker as presented in Table 10.6.29 for surface soils. Hazard-based RGOs were calculated based on the hypothetical child resident or site worker, as noted in the table.

Groundwater

Groundwater RGOs based on the site resident and site worker scenarios are shown in Table 10.6.30.

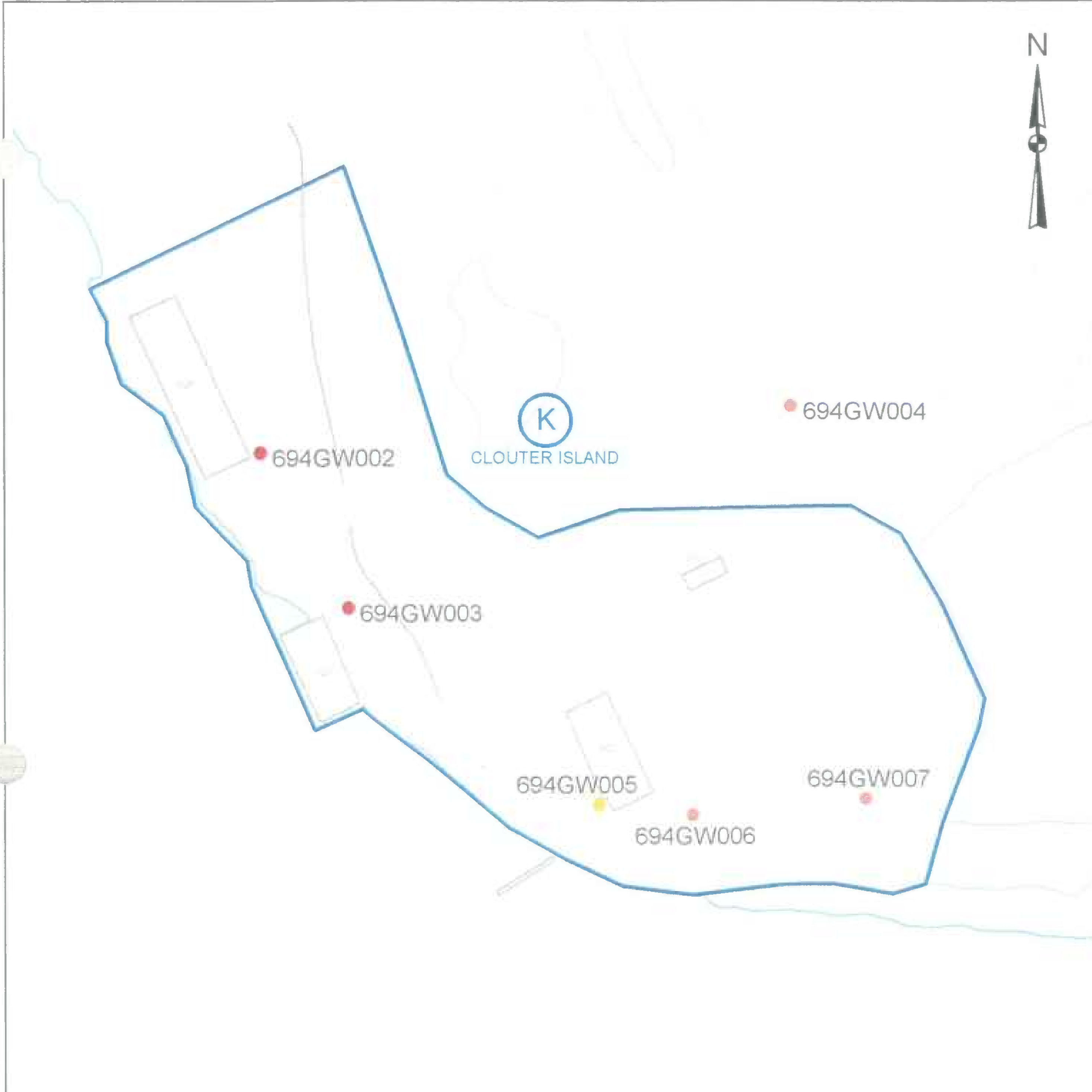
10.6.7 Corrective Measures Considerations

For AOC 693 and AOC 694, the upper and lower soil intervals and shallow groundwater were investigated. A total of 27 upper and 12 lower-interval soil samples were collected. Seven groundwater monitoring well was sampled at the site. Based on the analytical results and the human health risk assessment, COCs requiring further evaluation through the CMS process were identified for the upper soil interval and groundwater.

Aluminum, antimony, arsenic, chromium, vanadium, and BEQs were identified as COCs in the upper soil interval. Each of these parameters were contributors to risk or HI. Copper and lead also contributed to risk. The soil pathway cumulative residential exposure risk is 5E-05 and the cumulative HI is 2 (resident child). Both are between USEPA's acceptable range of 1E-06 and 1E-04 for risk and 3 and 0.1 for HI.

Residential risk-based remedial goals for surface soil set for aluminum, antimony, arsenic, chromium, and BEQs based on a target risk of 1E-06 are shown on Table 10.6.28. Potential corrective measures, in addition to no further action for soil, and respective COCs are presented in Table 10.6.31.

Arsenic, cadmium, and manganese were identified as the COCs in the groundwater sample at AOC 693 and AOC 694. The residential-based risk associated with arsenic is 2E-03, which is below USEPA's acceptable range of 1E-06 and 1E-04. The cumulative residential-based HI was 22. Arsenic's residential-based remedial goal option for the shallow groundwater is 0.0005 mg/L,



LEGEND

- NO COPCs
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

100 0 100 200 Feet

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FIGURE 10.6.17
AOCs 693 and 694

POINT HAZARD ESTIMATES FOR
GROUNDWATER
RESIDENTIAL SCENARIO

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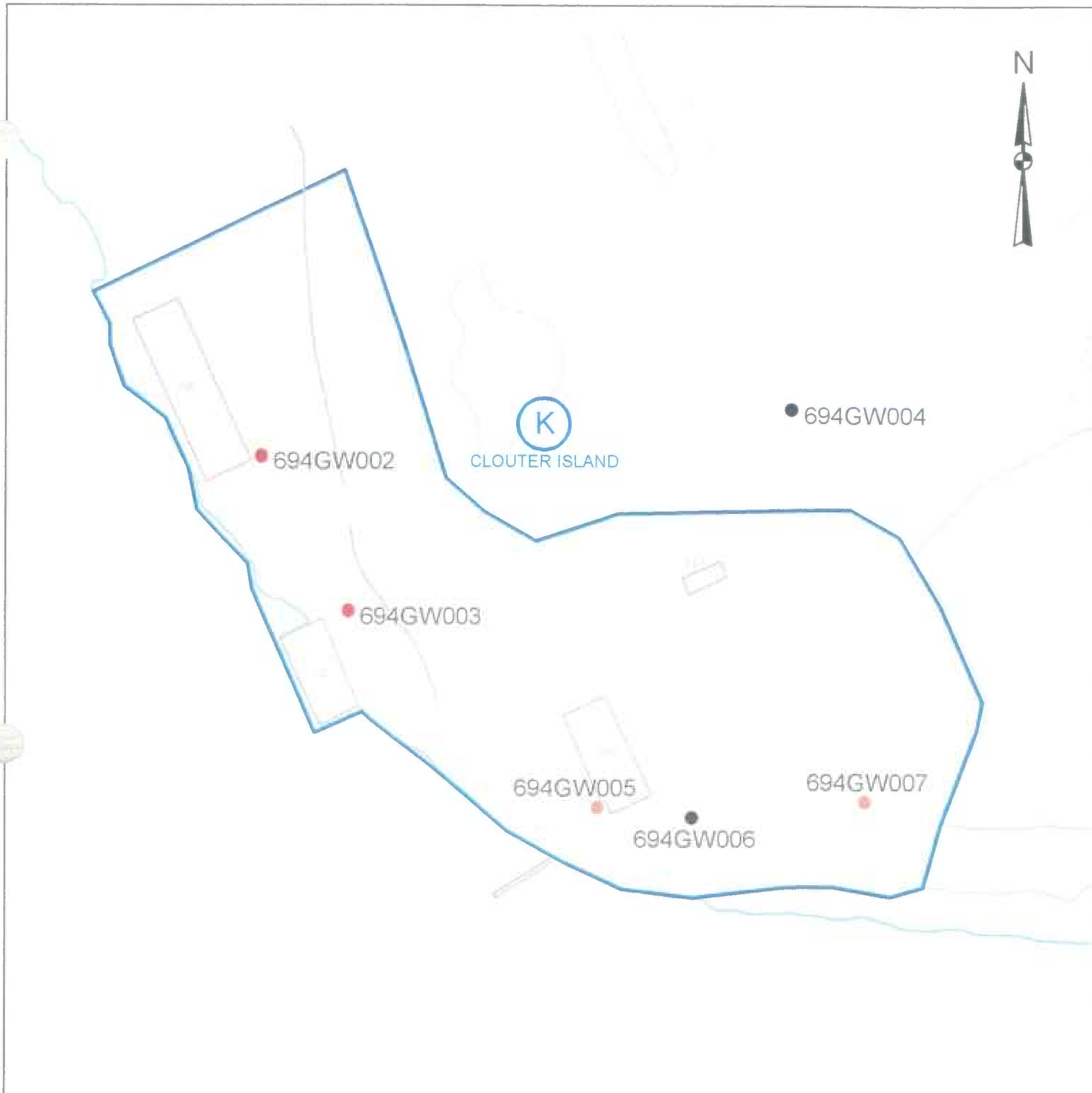

LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

100 0 100 200 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.6.18
AOCs 693 and 694

POINT RISK ESTIMATES FOR
GROUNDWATER
INDUSTRIAL SCENARIO

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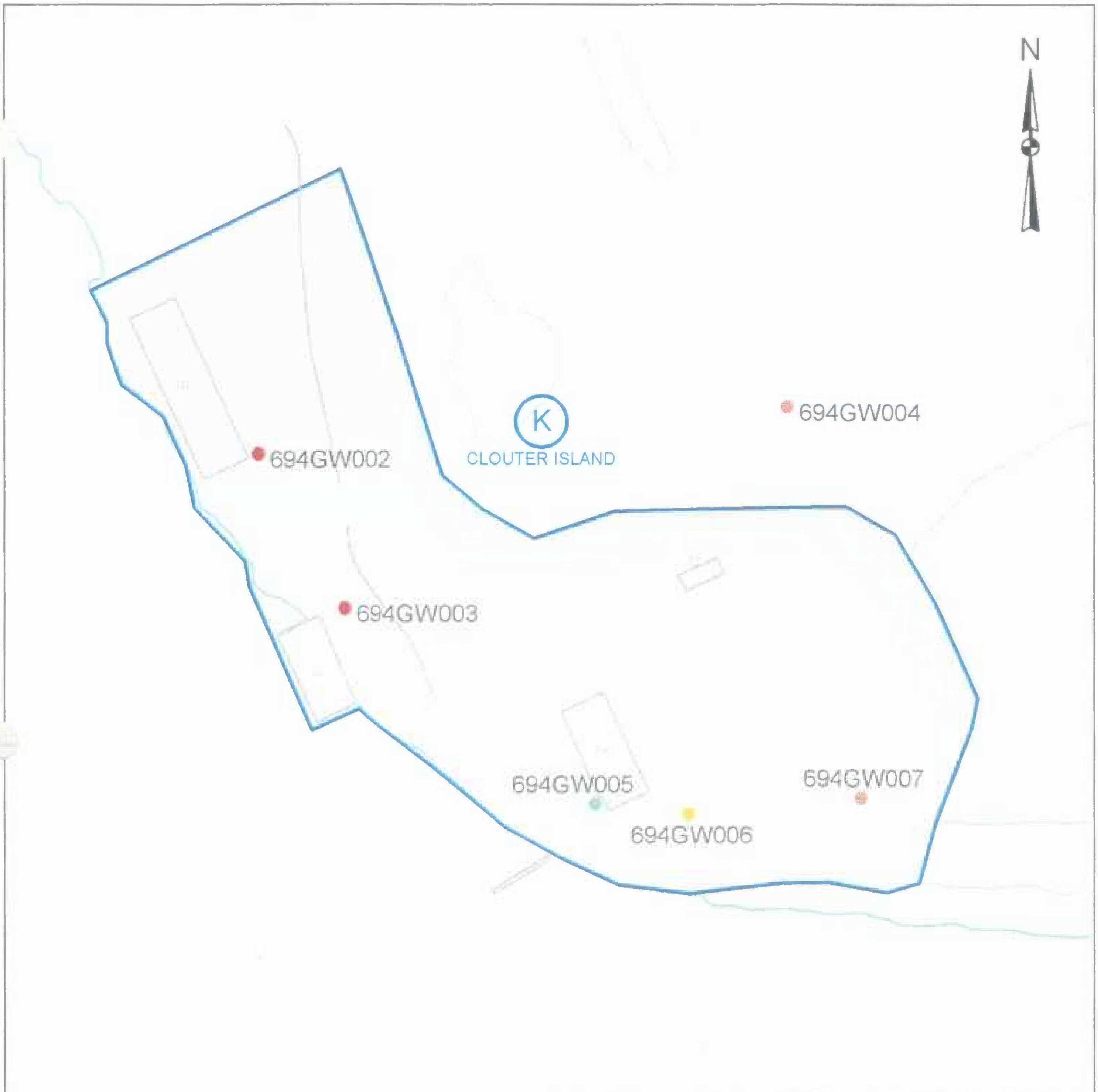

LEGEND

- NO COPCs
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

100 0 100 200 Feet

ZONE K - RCRA
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FIGURE 10.6.19
AOCs 693 and 694

POINT HAZARD ESTIMATES FOR
GROUNDWATER
INDUSTRIAL SCENARIO

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Table 10.6.28
Point Estimates of Risk and Hazard - Groundwater Pathways
Industrial Scenario
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Round	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
694	G002	01	Arsenic (As)	66.9	UG/L	4.36	66.36	701	100.00
			Manganese (Mn)	2600	UG/L	2.21	33.64	NA	
			Total			6.58		701	
694	G002	02	Arsenic (As)	63.3	UG/L	4.13	64.29	664	100.00
			Cadmium (Cd)	0.56	UG/L	0.02		NA	
			Manganese (Mn)	2670	UG/L	2.27	35.37	NA	
			Total			6.42		664	
694	G002	03	Arsenic (As)	57.7	UG/L	3.76	68.65	605	100.00
			Manganese (Mn)	2020	UG/L	1.72	31.35	NA	
			Total			5.48		605	
694	G002	04	Arsenic (As)	51.2	UG/L	3.34	68.20	537	100.00
			Manganese (Mn)	1830	UG/L	1.56	31.80	NA	
			Total			4.90		537	
694	G003	01	Arsenic (As)	43.2	UG/L	2.82	67.84	453	100.00
			Manganese (Mn)	1570	UG/L	1.34	32.16	NA	
			Total			4.15		453	
694	G003	02	Arsenic (As)	48.8	UG/L	3.18	70.44	512	100.00
			Manganese (Mn)	1570	UG/L	1.34	29.56	NA	
			Total			4.52		512	
694	G003	03	Arsenic (As)	38.9	UG/L	2.54	65.51	408	100.00
			Manganese (Mn)	1570	UG/L	1.34	34.49	NA	
			Total			3.87		408	
694	G003	04	Arsenic (As)	47.6	UG/L	3.11	69.92	499	100.00
			Manganese (Mn)	1570	UG/L	1.34	30.08	NA	
			Total			4.44		499	
694	G004	01	Cadmium (Cd)	2.1	UG/L	0.08	56.00	NA	
			Manganese (Mn)	75.9	UG/L	0.06	44.00	NA	
			Total			0.15		NA	
694	G004	02	Cadmium (Cd)	0.4	UG/L	0.02	2.06	NA	
			Manganese (Mn)	873	UG/L	0.74	97.94	NA	
			Total			0.76		NA	
694	G004	03	Manganese (Mn)	1250	UG/L	1.06		NA	
694	G004	04	Manganese (Mn)	1200	UG/L	1.02		NA	
694	G005	01	Manganese (Mn)	254	UG/L	0.22		NA	
694	G005	02	Arsenic (As)	3.2	UG/L	0.21	47.61	34	100.00
			Manganese (Mn)	270	UG/L	0.23	52.39	NA	
			Total			0.44		34	
694	G005	03	Manganese (Mn)	307	UG/L	0.26		NA	
694	G005	04	Arsenic (As)	2.4	UG/L	0.16	45.77	25	100.00
			Manganese (Mn)	218	UG/L	0.19	54.23	NA	
			Total			0.34		25	
694	G006	01	Arsenic (As)	3.4	UG/L	0.22	12.17	36	100.00
			Cadmium (Cd)	5.9	UG/L	0.23	12.67	NA	
			Manganese (Mn)	1610	UG/L	1.37	75.16	NA	
			Total			1.82		36	
694	G006	02	Manganese (Mn)	1660	UG/L	1.41		NA	
694	G006	03	Manganese (Mn)	1360	UG/L	1.16		NA	
694	G006	04	Manganese (Mn)	936	UG/L	0.80		NA	
694	G007	01	Manganese (Mn)	1330	UG/L	1.13		NA	
694	G007	02	Arsenic (As)	3	UG/L	0.20	9.23	31	100.00
			Cadmium (Cd)	19.3	UG/L	0.76	35.61	NA	
			Manganese (Mn)	1375	UG/L	1.17	55.16	NA	
			Total			2.12		31	
694	G007	03	Cadmium (Cd)	0.6	UG/L	0.02	2.81	NA	
			Manganese (Mn)	953.5	UG/L	0.81	97.19	NA	
			Total			0.83		NA	
694	G007	04	Arsenic (As)	2.5	UG/L	0.16	14.90	26	100.00
			Manganese (Mn)	1095	UG/L	0.93	85.10	NA	
			Total			1.09		26	

Table 10.6.29
Remedial Goal Options for Soil
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Inorganic										
Aluminum (Al)	NA	1	29947.5	218781	72927	7292.7	ND	ND	ND	32100
Antimony (Sb)	NA	0.0004	5.0	88	29	2.9	ND	ND	ND	2.16
Arsenic (As)	1.5	0.0003	17.2	66	22	2.2	0.38	3.8	38	23
Chromium (Cr)	NA	0.003	66.2	656	219	21.9	ND	ND	ND	69.1
Vanadium (V)	NA	0.007	66.9	1531	510	51.0	ND	ND	ND	75.9
Carcinogenic PAHs										
Benzo(a)pyrene equivalents	7.3	NA	0.4	ND	ND	ND	0.060	0.60	6.0	ND

Worker-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Inorganic										
Arsenic (As)	1.5	0.0003	17.2	1305	435	43	2.7	27	271	23
Carcinogenic PAHs										
Benzo(a)pyrene equivalents	7.3	NA	0.4	ND	ND	ND	0.30	3.0	30	ND

NOTES:
EPC Exposure point concentration
NA Not applicable
ND Not determined
- Remedial goal options were based on the residential or site worker lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens

Table 10.6.30
Residential-Based Remedial Goal Options Shallow Groundwater
AOCs 693 and 694
Charleston Naval Complex, Zone K
Charleston, South Carolina

Residential-Based Remedial Goal Options

				Hazard-Based Remedial Goal Options			Risk-Based Remedial Goal Options				
Chemical	Oral SF $(mg/kg\text{-}day)^{-1}$	Oral RfD (mg/kg-day)	EPC mg/l	**0.1** mg/l	**1.0** mg/l	**3** mg/l	**1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	MCL mg/l	Background Concentration mg/l
Arsenic (As)	1.5	0.0003	0.067	0.00047	0.0047	0.014	0.000044	0.00044	0.0044	0.05	0.0151
Cadmium (Cd)	NA	0.0005	0.0020	0.00078	0.0078	0.023	ND	ND	ND	0.005	0.0004
Manganese (Mn)	NA	0.023	2.2	0.036	0.36	1.1	ND	ND	ND	NA	1.21

Worker-Based Remedial Goal Options

				Hazard-Based Remedial Goal Options			Risk-Based Remedial Goal Options				
Chemical	Oral SF (mg/kg-day)-1	Oral RfD (mg/kg-day)	EPC mg/l	**0.1** mg/l	**1** mg/l	**3** mg/l	**1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	MCL mg/l	Background Concentration mg/l
Arsenic (As)	1.5	0.0003	0.067	0.0031	0.031	0.092	0.00014	0.0014	0.014	0.05	0.0151
Cadmium (Cd)	NA	0.0005	0.0020	0.0051	0.051	0.15	ND	ND	ND	0.005	0.0004
Manganese (Mn)	NA	0.023	2.2	0.24	2.4	7.1	ND	ND	ND	NA	1.21

NOTES:

EPC exposure point concentration
NA not applicable
ND not determined
- residential remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

cadmium is 0.0008 mg/L, and manganese is 0.036 mg/L. Potential corrective measures and respective COCs are presented in Table 10.6.31.

Table 10.6.31
Potential Corrective Measures for AOC 693 and AOC 694

Medium	Compounds	Potential Corrective Measures
Soil	Aluminum, antimony, arsenic, chromium, vanadium, benzo(a)pyrene equivalents	a) No Action b) Intrinsic remediation and monitoring c) Containment by capping d) Excavation and landfill, if RCRA-nonhazardous waste e) Insitu, chemical and physical treatment f) Exsitu, chemical and physical treatment
Shallow Groundwater	Arsenic, cadmium, and manganese	a) No Action b) Intrinsic remediation and monitoring c) Insitu, chemical and physical treatment d) Exsitu, chemical and physical treatment

10.7 AOC 695, Electric Locomotive Shed, Former Building 119, Clouter Island

AOC 695 consists of former Building 119, an electric locomotive shed, which operated from approximately 1922 until 1925, as shown on CNC Charleston maps (Figure 10.7.1). No other information is available regarding the design features, dimensions, or operating practices of the shed. Upon review of a 1926 map of the Naval Ammunition Depot (obtained after the 1995 RFA was prepared), the original location of Building 119 was determined to be on a railroad trestle which extended over the Cooper River. The map indicated that this shed was on a spur constructed at the river's shoreline. Since 1929, however, the shoreline has apparently receded and the location of the AOC is now approximately 50 to 100 feet offshore. No records were obtained which document the demolition and removal of this structure. Waste materials associated with this AOC include solvents and degreasers.

Materials of concern at AOC 695 included solvents and degreasers. The ecology of the Cooper River is also a potential receptor. These receptors are benthic organisms and bottom dwellers and species that prey on bottom dwellers.

To fulfill CSI objectives, sediment was sampled in accordance with the final RFI work plan and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at AOC 695.

10.7.1 Sediment Sampling and Analysis

Sediment was sampled in one round at AOC 695 from the locations shown on Figure 10.7.1. The final RFI work plan proposed collection of two sediment samples for the AOC 695 investigation area. The sampling occurred during the field investigation for Zone J.

First-round samples were submitted for analysis at DQO Level III for VOCs, SVOCs, metals, pesticides, PCBs, cyanide, hexavalent chromium, organotins, redox, TOC and CEC. Table 10.7.1 summarizes sediment sampling for AOC 695.

Table 10.7.1
AOC 695
Sediment Sampling Summary

Sampling Round	Sampling Date	Samples Collected	Sample Analyses	Comments
1		2 (2)	Standard suite, organotins hex-chrome, redox, TOC, CEC	More comprehensive suite of analytical parameters chosen to complement the Zone J sediment samples.

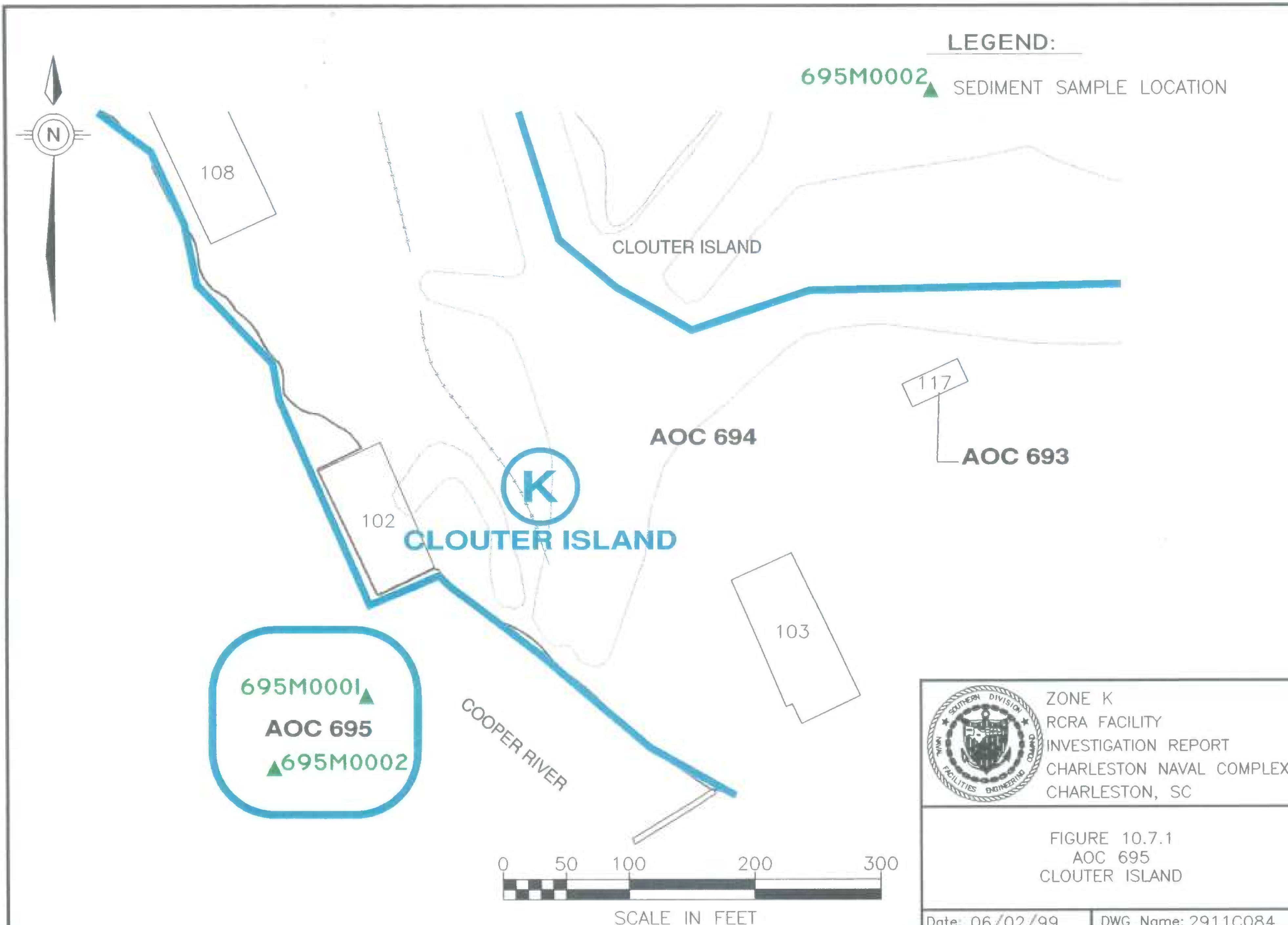
Notes:
( ) = Parenthes indicate number of samples proposed in the RFI work plan.
Standard Suite = VOCs, SVOCs, metals, cyanide, pesticides and PCBs at DQO Level III

10.7.2 Nature and Extent of Contamination in Sediment

No organic compounds were detected in sediment at AOC 695. Inorganic analytical results are summarized in Table 10.7.2. Table 10.7.3 summarizes all analytes detected in sediment at AOC 695. Appendix F is a complete analytical data report for all samples collected in Zone K, including AOC 695.

Inorganics in Sediment

Eighteen metals were detected in sediment at AOC 695 (Table 10.7.2). SSVs, when available, are provided in Table 10.7.2 for comparison purposes. Background concentrations of these compounds are being determined as part of the Zone J RFI. Complete sediment sample assessment, including comparison to SSVs and background screening concentrations, will be provided in the Zone J RFI.



ZONE K
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.7.1
AOC 695
CLOUTER ISLAND

Date: 06/02/99 | DWG Name: 2911C084

Physico-Chemical Analytical Parameters

Total organic carbon (TOC) was 5% and 6% of each of the sediment samples. Redox was 157 millivolts (mv) and 232 mv for the two samples. The cation exchange capacity (CEC) for the two samples was 83.4 milliequivalents (me) and 92me.

10.7.3 Fate and Transport Assessment for AOC 695

Cooper River sediment was the only environmental medium sampled as part of the AOC 695 RFI. The potential constituent migration pathway investigated for AOC 695 was sediment to surface water. The AOC 695 sediment data will be considered as part of the Zone J fate and transport assessment.

10.7.4 Human Health Risk Assessment for AOC 695

A human health risk assessment was not conducted for this site. Human health and its relationship with Cooper River sediments will be addressed in the Zone J RFI.

10.7.5 Corrective Measures Considerations

For AOC 695, the sediments were investigated. Any CMS will be considered during Zone J's CMS.

Table 10.7.2
AOC 695
Inorganics Detected in Sediment
(all results reported in mg/kg)

Parameter	Sample Interval	Detection Frequency	Detections Range	Mean	SSV	Number of Samples Exceeding SSV
Aluminum	0-6"	2/2	29,900 - 33,300	31,600	NL	NA
Arsenic	0-6"	2/2	15.5 - 17.7	16.6	7.24	2
Barium	0-6"	2/2	30.1 - 33	31.6	NL	NA
Beryllium	0-6"	2/2	1.5 - 1.6	1.6	NL	NA
Calcium	0-6"	2/2	6,000 - 6,770	6,385	NL	NA

Table 10.7.2
AOC 695
Inorganics Detected in Sediment
(all results reported in mg/kg)

Parameter	Sample Interval	Detection Frequency	Detections Range	Mean	SSV	Number of Samples Exceeding SSV
Chromium	0-6"	2/2	57.7 - 60.3	59	52.3	2
Cobalt	0-6"	2/2	7.2 - 7.3	7.3	NL	NA
Copper	0-6"	2/2	9.1 - 9.6	9.4	18.7	0
Iron	0-6"	2/2	30,000 - 32,300	31,150	NL	NA
Lead	0-6"	2/2	13.9 - 14.8	14.4	30.2	0
Magnesium	0-6"	2/2	7,280 - 7,750	7,515	NL	NA
Manganese	0-6"	2/2	255 - 301	278	NL	NA
Nickel	0-6"	2/2	17 - 17.4	17.2	15.9	1
Potassium	0-6"	2/2	4,370 - 4,940	4,655	NL	NA
Sodium	0-6"	2/2	10,100 - 11,600	10,850	NL	NA
Thallium	0-6"	2/2	3.3	NA	NL	NA
Vanadium	0-6"	2/2	61.4 - 66.2	63.8	NL	NA
Zinc	0-6"	2/2	53.5 - 64.5	59	124	0

Notes:
NL = Not listed
NA = Not applicable/not available/not analyzed
SSV = Sediment Screening Value

Table 10.7.3
AOC 695
Analytes Detected in Sediment (mg/kg)

Parameter	Sample Location	Concentration	SSV
Inorganic Chemicals (2 Samples Collected)			
Aluminum	695M0001	33,300	NL
	695M0002	29,900	
Arsenic	695M0001	**17.7**	7.24
	695M0002	**15.5**	
Barium	695M0001	33	NL
	695M0002	30.1	
Beryllium	695M0001	1.6	NL
	695M0002	1.5	

Table 10.7.3
AOC 695
Analytes Detected in Sediment (mg/kg)

Parameter	Sample Location	Concentration	SSV
Calcium	695M0001	6,000	NL
	695M0002	6,770	
Chromium	695M0001	**60.3**	52.3
	695M0002	**57.7**	
Cobalt	695M0001	7.3	NL
	695M0002	7.2	
Copper	695M0001	9.6	18.7
	695M0002	9.1	
Iron	695M0001	32,300	NL
	695M0002	30,000	
Lead	695M0001	14.8	30.2
	695M0002	13.9	
Magnesium	695M0001	7,750	NL
	695M0002	7,280	
Manganese	695M0001	255	NL
	695M0002	301	
Nickel	695M0001	**17**	15.9
	695M0002	**17.4**	
Potassium	695M0001	4,940	NL
	695M0002	4,370	
Sodium	695M0001	11,600	NL
	695M0002	10,100	
Thallium	695M0001	ND	NL
	695M0002	3.3	
Vanadium	695M0001	66.2	NL
	695M0002	61.4	
Zinc	695M0001	64.5	124
	695M0002	53.5	
Cation Exchange Capacity (ME)			
Cation Exchange Capacity	695M0001	83.4	NL
	695M0002	92	
Total Organic Carbon (TOC)(%)			
Total Organic Carbon (TOC)	695M0001	6	NL
	695M0002	5	

Table 10.7.3
AOC 695
Analytes Detected in Sediment (mg/kg)

Parameter	Sample Location	Concentration	SSV
REDOX (MV)			
REDOX	695M0001	157	NL
	695M0002	232	

Notes:
Bolded concentrations exceed the SSV
NL = Not listed
mg/kg = Milligrams per kilogram
SSV = Sediment Screening Value
ME = Milliequivalent
MV = Millivolt

10.8 AOC 696, Transformer Area Near Building 2509, Naval Annex

AOC 696 consists of an area where five transformers were located on a 6-inch thick concrete slab immediately north of Building 2509 at the Naval Annex (Figure 10.8.1). Building 2509, which was constructed in 1962, housed a radar station that was operational until 1981, at which time the property was transferred from the Air Force to the Navy and the radar station was dismantled. The Navy used the eight-story tower for mine storage until 1993.

In 1991, the dielectric fluid from all five transformers was sampled and determined to contain less than 50 parts per million PCBs. Two fire damaged transformers were removed at that time, the three remaining transformers supplied power to Building 2509. In early 1997, when the three remaining transformers were out of service, they were sampled again. The dielectric fluid of two of the remaining transformers contained PCB concentrations exceeding 50 ppm. Areas of stressed vegetation were noted near the transformer pad (Figure 10.8.1).

In late 1997, the CEERD implemented the AOC 696 Interim Measures, which included the demolition and disposal of the transformer station (remaining three transformers, fence, concrete slab), excavation and disposal of approximately 10 $yd^3$of beryllium- and arsenic-contaminated soil, excavation and disposal of approximately 40 yd^3 of PCB-contaminated soil, and collection of confirmation samples to verify the integrity of the site remedial measures. The results of the confirmation sampling indicated concentrations of arsenic and PCBs exceeding the established clean-up levels. Using past investigative data and further sampling, the areas of remaining contamination were identified and approximately 30yd^3 of additional impacted soil were removed and disposed of. Refer to the Completion Report, Interim Measure for AOC 696, for detailed descriptions of remedial procedures, sampling methods and waste disposal.

A 1000 gallon fuel oil UST was installed on the north side of Building 2509 in 1962. No records are known that document removal of the tank or any associated releases to the environment. Also, the condition of the tank is unknown at present. It has been out of service since the radar station was dismantled in 1981.

Materials of concern identified in the final RFI work plan (E/A&H, September 1996) for AOC 696 were PCBs and petroleum hydrocarbons. Potential receptors are current and future site users involved in invasive activities.

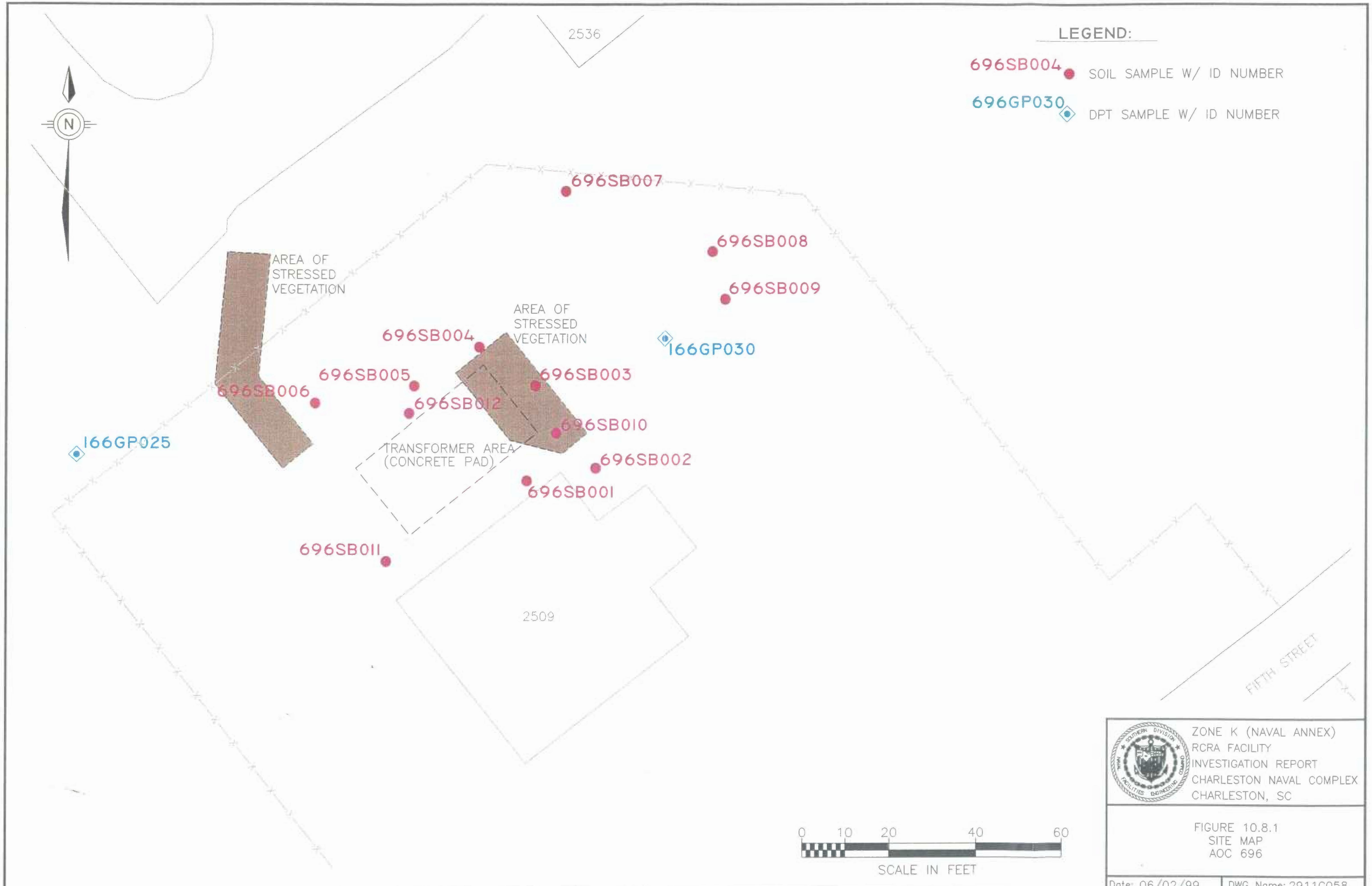
To fulfill CSI objectives, soil was sampled in accordance with the final RFI work plan, and as described in Section 3 of this report, to confirm whether any contamination resulted from onsite activities at AOC 696.

10.8.1 Soil Sampling and Analysis

Soil was sampled in three rounds at AOC 696 from the locations shown on Figure 10.8.1. The final RFI work plan proposed collection of six soil samples from the upper-interval (0 to 1 foot) and six from the lower-interval (3 to 5 feet) for the AOC 696 investigation area. Each of these samples were collected during the first round of sampling.

The first round of sampling occurred in November 1996 during the Zone K field investigation. In the 696SB00301 sample, PCBs exceeded their RBC. As part of the second-round sampling, three additional upper-interval soil samples were collected in February 1997. During the third sampling round in February 1998, three additional upper- and lower-interval samples were collected.

First-round samples were submitted for analysis at DQO Level III for PCBs and TPH. One duplicate was also collected from boring 696SB001's upper-interval and submitted for Appendix IX analyses at DQO Level IV. Second-round samples were submitted for PCB


LEGEND:
696SB004 SOIL SAMPLE W/ ID NUMBER
696GP030 DPT SAMPLE W/ ID NUMBER
N
2536
696SB007
696SB008
696SB009
AREA OF STRESSED VEGETATION
AREA OF STRESSED VEGETATION
696SB004
166GP030
696SB005
696SB003
696SB006
696SB012
696SB010
166GP025
TRANSFORMER AREA (CONCRETE PAD)
696SB002
696SB001
696SB011
2509
FIFTH STREET
0 10 20 40 60
SCALE IN FEET
ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.8.1
SITE MAP
AOC 696
Date: 06/02/99
DWG Name: 2911C058

00149T152

analysis at DQO Level III. Third-round samples were submitted only for metals analysis at DQO Level III. Table 10.8.1 summarizes all sampling for AOC 696.

Table 10.8.1
AOC 696
Soil Sampling Summary

Sampling Round	Sampling Date	Samples Collected	Sampling Analysis	Comments
1	11/18 - 19/96	Upper - 6 (6) Lower - 6 (6) Duplicate - 1	PCBs and TPH Appendix IX and TPH	None
2	2/13 - 14/97	Upper - 3 (0)	PCBs	Three additional samples were collected for site characterization during round 2.
3	2/26/98	Upper - 3 (0) Lower - 3 (0)	Metals	Three additional samples were collected for metals in round 3.

Note:
( ) = Parentheses indicate number of samples proposed in RFI work plan
Appendix IX = Standard suite plus hex-chrome, herbicides, OP pesticides,and dioxins at DQO Level IV.

10.8.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.8.2. Inorganic chemical analytical results are summarized in Table 10.8.3. Table 10.8.4 summarizes all analytes detected in AOC 696 soil. Analyte concentrations are listed in both type if they exceeded their respective screening concentrations, the applicable residential soil RBC or SSL and, when available, the associated background concentration. Appendix F is a complete analytical data report for all Zone K samples, including AOC 696.

Table 10.8.2
AOC 696
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Pesticides (µg/kg) 12 samples collected, 6 upper-interval samples, 6 lower-interval samples, 1 duplicate						
Alpha-Chlordane	Upper	1/6	2.06	2.06	1,800[a]	0
	Lower	0/6	ND	NA	5,000	0
4,4'-DDD	Upper	2/6	4.75 - 5.71	5.23	2,700	0
	Lower	0/6	ND	NA	8,000	0
4,4'-DDE	Upper	6/6	4.65 - 29.1	17.8	1,900	0
	Lower	0/6	ND	NA	27,000	0
4,4'-DDT	Upper	5/6	9.62 - 60.5	28.9	1,900	0
	Lower	1/6	6.93	6.93	16,000	0
Dieldrin	Upper	1/6	26.8	26.8	40	0
	Lower	0/6	ND	NA	2.0	0
Endosulfan II	Upper	1/6	64.8	64.8	4,7000 [b]	0
	Lower	0/6	ND	ND	9,000 [b]	0
Endosulfan sulfate	Upper	1/6	28.1	28.1	47,000[b]	0
	Lower	0/6	ND	ND	4,600	0
Endrin aldehyde	Upper	1/6	82.8	82.8	2,300 [c]	0
	Lower	0/6	ND	ND	340	0
Heptachlor epoxide	Upper	1/6	16.8	16.8	70	0
	Lower	0/6	ND	ND	330	0
gamma-Chlordane	Upper	1/6	20.5	20.5	1,800	0
	Lower	0/6	ND	ND	5,000	0
PCBs (µg/kg) 15 samples collected, 9 upper-interval samples and 6 lower-interval samples, 1 duplicate.						
Aroclor-1260	Upper	2/9	106 - 1780	943	320	1
	Lower	1/6	93.5	93.5	1,000	1
TPH - Diesel Range Organics (mg/kg) 12 samples collected, 6 upper-interval samples, 6 lower-interval samples, 1 duplicate						
Diesel	Upper	3/6	16.6 - 108	58.9	100[d]	NA
	Lower	0/6	ND	ND	100[d]	NA

Table 10.8.2
AOC 696
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Dioxin (ng/kg)						
1 duplicate sample collected from lower-interval						
TCDD TEQ	Upper	1/1	0.12	0.12	4.3	0
	Lower	0/0	NT	NT	1,600	0

Notes:
a = RBC and SSL are not listed for alpha-chlordane. RBC and SSL for chlordane were used as a surrogate.
b = RBC and SSL for endosulfan sulfate are not listed. RBC and SSL for endosulfan were used as a surrogate.
c = RBC and SSL for endrin aldehyde are not listed. RBC and SSL for endrin were used as a surrogate.
d = Charleston Naval Complex project screening level.

Table 10.8.3
AOC 696
Inorganics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Inorganics							
1 Duplicate sample from the upper-interval							
Aluminum	Upper	4/9	5,110 - 8,460	6,870	11,200	7,800	0
	Lower	3/9	6,630 - 12,100	9,163	10,500	560,000	0
Antimony	Upper	1/9	0.42	0.42	0.45	3.1	0
	Lower	0/9	ND	ND	NA	2.7	0
Arsenic	Upper	4/9	2.7 - 5.4	4.00	3	0.43[a]	3
	Lower	1/9	0.9	0.90	1.98	15	0
Barium	Upper	4/9	11.6 - 15.8	13.7	25.6	550	0
	Lower	3/9	6.7 - 10	8.03	6.83	820	0
Beryllium	Upper	4/9	0.1 - 0.19	0.15	0.17	16	0
	Lower	2/9	0.06 - 0.08	0.07	0.12	32	0
Cadmium	Upper	3/9	0.27 - 2.8	1.20	0.13	3.9	0
	Lower	0/9	ND	ND	NA	4	0
Calcium	Upper	4/9	1,580 - 4,370	2,540	NA	NL	NA
	Lower	3/9	331 - 475	415	NA	NL	NA
Chromium	Upper	4/9	6.4 - 9.6	8.20	8.4	23	0
	Lower	3/9	6.4 - 9.6	7.70	8.76	19	0
Cobalt	Upper	3/9	0.61 - 1.6	0.99	0.34	470	0
	Lower	3/9	0.16 - 0.28	0.22	0.62	990	0
Copper	Upper	4/9	3.5 - 13.5	6.45	3.86	310	0
	Lower	3/9	1.7 - 2.7	2.07	0.34	5,600	0

Table 10.8.3
AOC 696
Inorganics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Iron	Upper	4/9	2,000 - 5,000	3,700	7,060	2,300	0
	Lower	3/9	630 - 1,820	1,066	5,130	NL	0
Lead	Upper	4/9	9.7 - 45.8	24.3	39.6	400[b]	0
	Lower	3/9	4.4 - 6.3	5.33	6.43	400[b]	0
Magnesium	Upper	4/9	219 - 374	289	NA	NL	NA
	Lower	3/9	183 - 196	188	NA	NL	NA
Manganese	Upper	4/9	11.3 - 30.2	18.7	26.4	160	0
	Lower	3/9	4.7 - 7.3	5.60	5.93	480	0
Nickel	Upper	4/9	1.9 - 3.8	2.98	1.7	160	0
	Lower	3/9	2.1 - 2.3	2.17	2.64	65	0
Potassium	Upper	4/9	141 - 318	204	NA	NL	NA
	Lower	3/9	145 - 167	157	NA	NL	NA
Selenium	Upper	2/9	0.36 - 0.39	0.38	0.84	39	0
	Lower	2/9	0.68 - 0.73	0.71	0.52	2.6	0
Sodium	Upper	4/9	44.5 - 298	196	NA	NL	NA
	Lower	3/9	208 - 234	221	NA	NL	NA
Tin	Upper	2/9	1.1 - 2.7	1.90	19.4	4,700	0
	Lower	3/9	1.1 - 1.2	1.13	NA	5,500	0
Vanadium	Upper	4/9	7.3 - 14.5	10.2	15.8	55	0
	Lower	3/9	5.3 - 9.2	6.73	12.2	3,000	0
Zinc	Upper	4/9	21 - 538	182	14.8	2,300	0
	Lower	3/9	4 - 16.1	8.07	NA	6,200	0

Notes:
a - Arsenic as a carcinogen
b - RBC for lead is not available. USEPA residential soil cleanup level was used for comparison (OSWER Directive 9355.4-12).
NA - Not applicable/not available/not analyzed
NL - Not listed
ND - Not detected/not determined

Table 10.8.4
AOC 696
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Pesticides/PCBs (μg/kg)							
4,4-DDD	696SB002	5.71	2,700	NA	ND	8,000	NA
	696SB005	4.75			ND		
4,4-DDE	696SB001	9.295	1,900	NA	ND	2,700	NA
	696SB002	21.7			ND		
	696SB003	29.1			ND		
	696SB004	16.6			ND		
	696SB005	25.7			ND		
	696SB006	4.65			ND		
4,4-DDT	696SB001	13.65	1,900	NA	ND	1,600	NA
	696SB002	60.5			ND		
	696SB004	50.3			6.93		
	696SB005	10.5			ND		
	696SB006	9.62			ND		
alpha-Chlordane	696SB002	2.06	1,800	NA	ND	5,000	NA
Aroclor-1260	696SB003	1,780	320	NA	93.5	1,000	NA
	696SB004	106			ND		
Dieldrin	696SB003	26.8	40	NA	ND	2	NA
Endosulfan II	696SB003	64.8	47,000	NA	ND	9,000	NA
Endosulfan sulfate	696SB003	28.1	47,000	NA	ND	4,600	NA
Endrin aldehyde	696SB003	82.8	47,000	NA	ND	340	NA
gamma-Chlordane	696SB003	20.5	1,800	NA	ND	500	NA
Heptachlor epoxide	696SB003	16.8	70	NA	ND	330	NA

Table 10.8.4
AOC 696
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Dioxin Compounds (ng/kg)							
TCDD TEQ	696CB001	0.12	4.3	NA	NT	1,600	NA
1234678-HpCDD	696CB001	4.17	430	NA	NT	110,000	NA
OCDD	696CB001	80.5	4,300	NA	NT	1,100,000	NA
OCDF	696CB001	0.562	4,300	NA	NT	540,000	NA
TPH-DRO (mg/kg)							
Diesel	696SB004	**108**	100 [a]	NA	ND	100 [a]	NA
	696SB005	52.1			ND		
	696SB006	16.6			ND		
Inorganics (mg/kg)							
Aluminum (Al)	696SB001	6,150	7,800	11,200	NT	560,000	10,500
	696SB010	5,110			**12,100**		
	696SB011	8,460			6,630		
	696SB012	7,760			8,760		
Antimony (Sb)	696SB001	0.42	3.1	0.45	NT	2.7	NA
Arsenic (As)	696SB001	**5.4**	0.43[a]	3	NT	15	1.98
	696SB010	**3.5**			ND		
	696SB011	**4.4**			0.9		
	696SB012	**2.7**			ND		
Barium (Ba)	696SB001	11.6	550	25.6	NT	820	6.83
	696SB010	13			7.4		
	696SB011	14.2			6.7		
	696SB012	15.8			10		

Table 10.8.4
AOC 696
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Beryllium (Be)	696SB001	0.18	16	0.17	NT	32	0.12
	696SB010	0.19			0.08		
	696SB011	0.1			ND		
	696SB012	0.13			0.06		
Cadmium (Cd)	696SB001	2.8	3.9	0.13	NT	4	NA
	696SB011	0.27			ND		
	696SB012	0.52			ND		
Calcium (Ca)	696SB001	2,280	NL	NA	NT	NL	NA
	696SB010	1,580			475		
	696SB011	1,930			331		
	696SB012	4,370			439		
Chromium (Cr)	696SB001	6.4	23	8.4	NT	19	8.76
	696SB010	8.3			9.6		
	696SB011	8.5			7.1		
	696SB012	9.6			6.4		
Cobalt (Co)	696SB010	1.6	470	0.34	0.21	990	0.62
	696SB011	0.61			0.28		
	696SB012	0.76			0.16		
Copper (Cu)	696SB001	4.4	310	3.86	NT	5,600	0.34
	696SB010	4.4			2.7		
	696SB011	3.5			1.8		
	696SB012	13.5			1.7		
Iron (Fe)	696SB001	2,000	2,300	7060	NT	NL	5130
	696SB010	4,110			630		
	696SB011	5,000			1,820		
	696SB012	3,690			749		

Table 10.8.4
AOC 696
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Lead (Pb)	696SB001	9.7	400[b]	39.6	NT	400	6.43
	696SB010	15.7			6.3		
	696SB011	25.8			4.4		
	696SB012	45.8			5.3		
Magnesium (Mg)	696SB001	219	NL	NA	NT	NL	NA
	696SB010	374			183		
	696SB011	307			196		
	696SB012	256			184		
Manganese (Mn)	696SB001	11.3	160	26.4	NT	480	5.93
	696SB010	30.2			4.7		
	696SB011	15.4			7.3		
	696SB012	18			4.8		
Nickel (Ni)	696SB001	3	160	1.7	NT	65	2.64
	696SB010	1.9			2.3		
	696SB011	3.2			2.1		
	696SB012	3.8			2.1		
Potassium (K)	696SB001	146	NL	NA	NT	NL	NA
	696SB010	318			167		
	696SB011	210			145		
	696SB012	141			158		
Selenium (Se)	696SB010	ND	39	0.84	0.68	2.6	0.52
	696SB011	0.36			ND		
	696SB012	0.39			0.73		
Sodium (Na)	696SB001	44.5	NL	NA	NT	NL	NA
	696SB010	223			234		
	696SB011	218			208		
	696SB012	298			220		

Table 10.8.4
AOC 696
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC* (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL* (DAF=10)	Subsurface Background
Tin (Sn)	696SB010	ND	4,700	19.4	1.1	5,500	NA
	696SB011	2.7			1.2		
	696SB012	1.1			1.1		
Vanadium (V)	696SB001	7.3	55	15.8	NT	3,000	12.2
	696SB010	8.9			5.7		
	696SB011	14.5			9.2		
	696SB012	10			5.3		
Zinc (Zn)	696SB001	538	2,300	14.8	NT	6,200	NA
	696SB010	21			16.1		
	696SB011	79.1			4.1		
	696SB012	91			4		

Notes:

a = Charleston Naval Complex project screening level
b = RBC not available for lead, USEPA residential soil cleanup level and for comparison.
* = Residential RBCs (THQ=0.1) were used as a reference concentration for upper-interval samples. Generic soil-to groundwater SSLs (DAF=10) from *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as a reference concentration for lower-interval samples.
Bold concentrations exceed the RBCs, or SSL, and the zone background.
All background values for Zone K are based on twice the means of the grid sample concentrations.
DAF = Dilution attenuation factor
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NT = Not taken
RBC = Risk-based concentration
SSL = Soil screening level
THQ = Target hazard quotient
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
ng/kg = Nanograms per kilogram
** = Number of nondetects prevented determination of background concentration

Pesticides/PCBs in Soil

Ten pesticide compounds were detected in the soil samples collected at AOC 696; all but one were in upper-interval samples. 4,4 -DDT was detected once in a lower-interval sample. However, the compounds 4,4 -DDT and 4,4'-DDE were widely detected; 4,4-DDE was detected in all six upper-interval samples. The remaining pesticides were detected in only one or two samples each. Many of the single pesticide detections were in upper-interval sample 696SB00301. None exceeded their respective RBCs.

One PCB (Aroclor-1260) was detected in AOC 696 soil samples. This compound was detected in upper-interval samples at two locations (696SB003 and 696SB004) and in the lower-interval at one (696SB003). Only the upper-interval concentration (1,780 μg/kg) at location 696SB003 exceeded the compound's RBC. It was not detected in the three additional samples collected during the second round of sampling to define the extent of Aroclor-1260 contamination at this location

Other Organic Compounds in Soil

Dioxin was detected in the duplicate sample collected at AOC 696. The calculated TEQ did not exceed the 2,3,7,8-TCDD RBC of 4.3 ng/kg.

TPH-DRO was detected in three (696SB004, 005, and 006) of the first-round upper-interval soil samples. Only one detection (108 mg/kg at location 696SB006) exceeded the 100 mg/kg TPH project screening concentration.

Inorganics in Soil

Arsenic was the only inorganic detected in AOC 696 samples that exceeded both its RBC and background concentrations. These exceedances were in surface sample locations 696SB001, 010, and 011 and the same order of magnitude as the RBC. Figure 10.8.2 shows where arsenic concentrations were detected in surface soil. Iron also exceeded its RBC screening concentration. However, all detected iron concentrations are below its surface and subsurface background concentrations.

10.8.3 Fate and Transport Assessment for AOC 696

Environmental media sampled as part of the AOC 696 RFI include surface soil and subsurface soil. The focus of the AOC 696 RFI was on PCBs and TPH and, as a result, most of the soil samples were analyzed for these substances only. Potential constituent migration pathways investigated for AOC 696 include soil to groundwater, and emission of volatiles from surface soil-to-air.

10.8.3.1 AOC 696 — Soil to Groundwater Cross-media Transport

Tables 10.8.5 and 10.8.6 compare maximum detected organic and inorganic constituent concentrations in surface soil and subsurface soil samples to risk-based soil screening levels considered protective of groundwater. To provide a conservative screen, generic soil screening levels are used; leachate entering the aquifer is assumed to be diluted by a ratio of 10:1, with no attenuation of constituents in soil (DAF=10).

Two organic compounds - Aroclor-1260 and dieldrin - were detected in AOC 696 soil above their respective groundwater protection SSLs. Aroclor-1260 was detected in two of nine upper-interval soil samples and in one of six lower-interval samples. The de facto groundwater protection screening level of 1,000 μg/kg was exceeded at only one location (1,780 μg/kg in the upper-interval sample at 696SB003). Dieldrin was detected in only one soil sample collected at AOC 696 (26.8 μg/kg, also in the upper-interval sample at 696SB003). The presence of these constituents in soil above their SSLs validates the pathway; groundwater data can support or refute this validation.

No inorganics were detected in AOC 696 soil at concentrations exceeding their corresponding groundwater protection SSLs.

10.8.3.2 AOC 696 — Soil-to-air Cross-media Transport

No VOCs were detected in surface soil samples collected at AOC 696. Arochlor-1260; however, was detected at one surface soil location at a concentration exceeding the soil-to-air SSL. Therefore, the soil-to-air pathway is valid, but the limited number of exceedances indicates it is not significant.

10.8.3.3 AOC 696 — Fate and Transport Summary

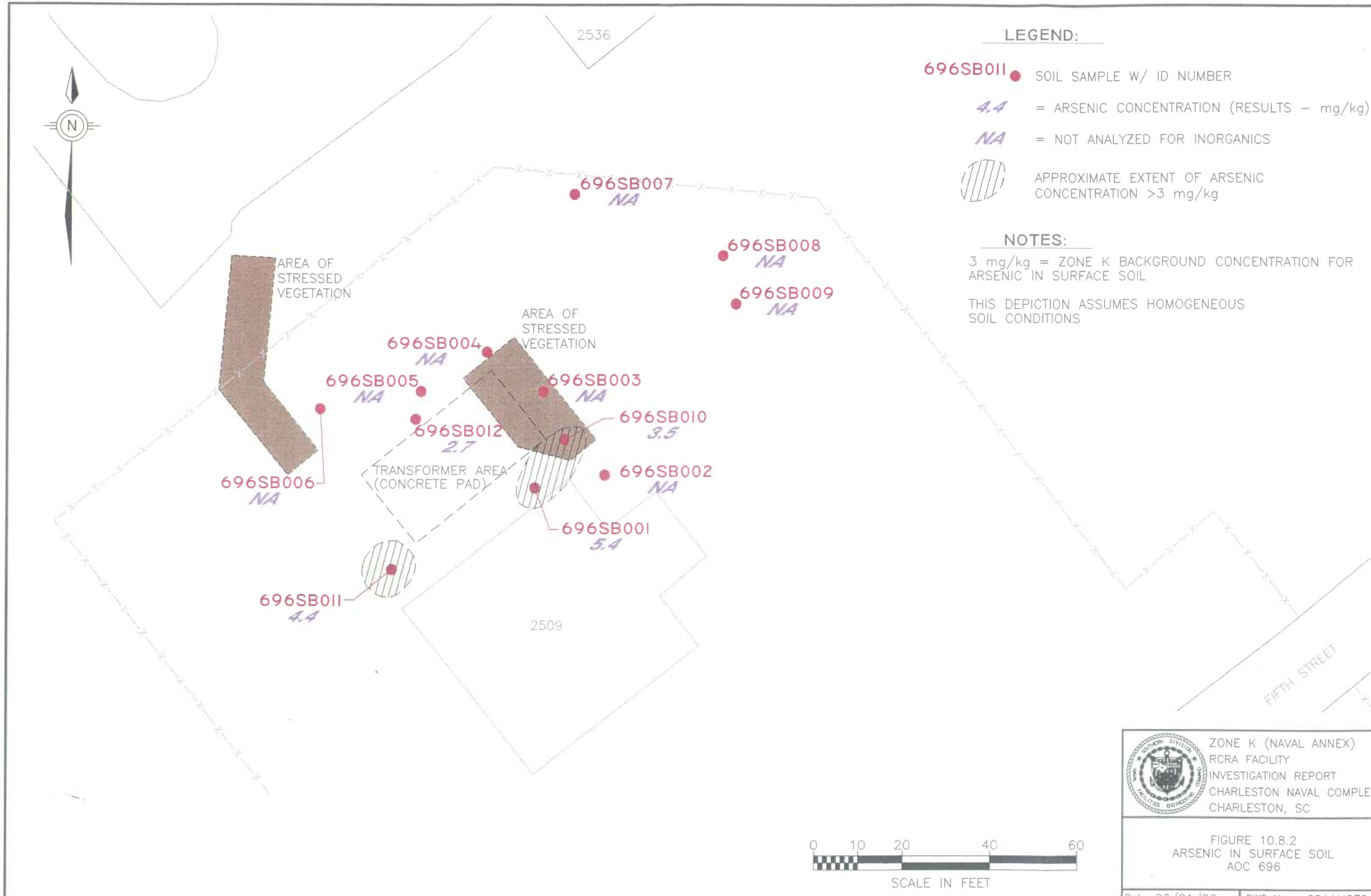
Two organic compounds detected in soil at AOC 696 were at concentrations that exceeded their respective groundwater protection screening levels. Without groundwater data, and with constituents present above SSLs, the pathway from soil-to-groundwater is considered valid. However, the infrequency of detection and number of exceedances suggests that the pathway may not be significant. Arochlor-1260 was present at only one location in surface soil at a concentration exceeding it soil-to-air SSL. As a result, that pathway is considered valid but is not expected to be significant.

No other fate and transport concerns were identified at AOC 696.

10.8.4 Human Health Risk Assessment for AOC 696

10.8.4.1 Site Background and Investigative Approach

AOC 696 is an area where five transformers were located immediately north of Building 2509 at the Naval Annex. Materials of concern due to past site operations are PCBs and petroleum hydrocarbons.



LEGEND:

696SB011 ● SOIL SAMPLE W/ ID NUMBER

4.4 = ARSENIC CONCENTRATION (RESULTS – mg/kg)

NA = NOT ANALYZED FOR INORGANICS

APPROXIMATE EXTENT OF ARSENIC CONCENTRATION >3 mg/kg

NOTES:

3 mg/kg = ZONE K BACKGROUND CONCENTRATION FOR ARSENIC IN SURFACE SOIL

THIS DEPICTION ASSUMES HOMOGENEOUS SOIL CONDITIONS

ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.8.2
ARSENIC IN SURFACE SOIL
AOC 696

Date: 06/01/99 | DWG Name: 2911M079

001497162

Table 10.8.5
Organic Compounds Detected in Surface Soil and Subsurface Soil
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, and Soil to Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: AOC 696
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurfac Soil	Shallow GW	Screening Concentration * Soil to GW SSL	Tap Water RBC	Soil to Air SSL	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Volatil-ization Potential
Pesticides/PCB Compounds											
Aroclor-1260 c	1780	93.5	NA	1000	0.033	1000	UG/KG	UG/L	YES	NO	YES
alpha-Chlordane c	2.06	ND	NA	5000 b	0.19	20000	UG/KG	UG/L	NO	NO	NO
gamma-Chlordane c	20.5	ND	NA	5000 b	0.19	20000	UG/KG	UG/L	NO	NO	NO
4,4'-DDD c	5.71	ND	NA	8000	0.28	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDE c	29.1	ND	NA	27000	0.2	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDT c	60.5	6.93	NA	16000	0.2	1.0E+09	UG/KG	UG/L	NO	NO	NO
Dieldrin c	26.8	ND	NA	2	0.0042	1000	UG/KG	UG/L	YES	NO	NO
Endosulfan II	64.8	ND	NA	9000 b	220	NA	UG/KG	UG/L	NO	NO	NO
Endosulfan sulfate	28.1	ND	NA	4600 a	220	NA	UG/KG	UG/L	NO	NO	NO
Endrin aldehyde	82.8	ND	NA	340 a	11	NA	UG/KG	UG/L	NO	NO	NO
Heptachlor epoxide c	16.8	ND	NA	330	0.0012	5000	UG/KG	UG/L	NO	NO	NO
Dioxin Compounds											
2378-TCDD Equivalents (TEQs) c	0.123	NA	NA	1600 a	0.45	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDD c	4.17	NA	NA	110000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDD c	80.5	NA	NA	1100000 a	450	NA	NG/KG	PG/L	NO	NO	NO
OCDF c	0.562	NA	NA	540000 a	450	NA	NG/KG	PG/L	NO	NO	NO
TPH - Diesel Range Organics											
Diesel	108000	ND	NA	NA	NA	NA	UG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.6.
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.8.2.

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Based on surrogate compound (See Table 5.6)
c - Carcinogen
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration

SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.8.6
Inorganic Chemicals Detected in Surface Soil and Subsurface Soil
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, Soil to Air SSLs, and Background Reference Values
Charleston Naval Complex, Zone K, Naval Annex: AOC 696
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurface Soil	Shallow GW	Screening Concentration Soil to GW SSL		Soil Background Reference	Soil to Air SSL	Tap Water RBC	GW Background Reference	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Fugitive Particulate Inhalation Concern
Inorganics														
Aluminum	8460	12100	NA	560000	a	11200	NA	37000	471	MG/KG	UG/L	NO	NO	NO
Antimony	0.42	ND	NA	2.7		0.45	NA	15	NA	MG/KG	UG/L	NO	NO	NO
Arsenic c	5.4	0.9	NA	15		3	750	0.045	NA	MG/KG	UG/L	NO	NO	NO
Barium	15.8	10	NA	820		25.6	690000	2600	31.2	MG/KG	UG/L	NO	NO	NO
Beryllium	0.19	0.08	NA	32		0.17	1300	73	NA	MG/KG	UG/L	NO	NO	NO
Cadmium	2.8	ND	NA	3.8		0.13	1800	18	NA	MG/KG	UG/L	NO	NO	NO
Chromium (total)	9.6	9.6	NA	19	b	8.76	270	110	NA	MG/KG	UG/L	NO	NO	NO
Cobalt	1.6	0.28	NA	990	a	0.62	NA	2200	NA	MG/KG	UG/L	NO	NO	NO
Copper	13.5	2.7	NA	5600	a	3.86	NA	1500	2.8	MG/KG	UG/L	NO	NO	NO
Lead	45.8	6.3	NA	400	d	39.6	400	15	1.9	MG/KG	UG/L	NO	NO	NO
Manganese	30.2	7.3	NA	480	a	26.4	NA	730	9.3	MG/KG	UG/L	NO	NO	NO
Nickel	3.8	2.3	NA	65		2.64	13000	730	NA	MG/KG	UG/L	NO	NO	NO
Selenium	0.39	0.73	NA	2.6		0.84	NA	180	NA	MG/KG	UG/L	NO	NO	NO
Tin	2.7	1.2	NA	5500	a	19.4	NA	22000	102	MG/KG	UG/L	NO	NO	NO
Vanadium	14.5	9.2	NA	3000		15.8	NA	260	0.8	MG/KG	UG/L	NO	NO	NO
Zinc	538	16.1	NA	6200		14.8	NA	11000	NA	MG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.7.
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Table 10.8.3.

Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Assumes hexachrome
c - Carcinogen
d - USEPA de facto residential soil level
GW - Groundwater
NA - Not available/Not applicable

ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

During the CSI, 12 soil samples were collected from the upper-interval and nine from the lower-interval to identify potential impacts resulting from site activities. Surface soil samples from all boring locations were used to quantitatively assess surface soil exposure pathways. Subsurface soil samples were addressed in the fate and transport assessment for AOC 696. No groundwater samples were collected as part of the AOC 696 CSI. Section 10.8.1 summarizes the sampling effort for AOC 696 soil.

10.8.4.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this RFI and presented in Table 10.8.7, Aroclor-1260 and arsenic were identified as COPCs in surface soil.

10.8.4.3 Exposure Assessment

Exposure Setting

AOC 696 is located on D Avenue, north of Building 2509 and south of Building 2536. A concrete pad in the middle of the site is in a fenced area, which also surrounds Building 2509.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed quantitatively in this risk assessment. Current exposure to workers is discussed qualitatively in relation to the future workers and future residents. The hypothetical future site worker scenario assumes continuous exposure to surface soil conditions.

Table 10.8.7
Chemicals Present in Site Samples
AOC 696 - Surface Soil
Charleston Naval Base, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
TPH - Diesel Range Organics													
Diesel		3	6	16.6	108	58.9	2.805	2.83	100	NA	MG/KG		
TCDD Equivalents													
1234678-HpCDD		1	1	4.17	4.17	4.17	NA	NA	NA	NA	NG/KG		
Dioxin Equiv.		1	1	0.1228	0.1228	0.1228	NA	NA	1000[a]	NA	NG/KG		
OCDD		1	1	80.5	80.5	80.5	NA	NA	NA	NA	NG/KG		
OCDF		1	1	0.562	0.562	0.562	NA	NA	NA	NA	NG/KG		
Inorganics													
Aluminum (Al)		4	4	5110	8460	6870	NA	NA	7800	11200	MG/KG		
Antimony (Sb)		1	4	0.42	0.42	0.42	0.83	1.1	3.1	0.45	MG/KG		
Arsenic (As)	*	4	4	2.7	5.4	4	NA	NA	0.43	3	MG/KG	4	3
Barium (Ba)		4	4	11.6	15.8	13.65	NA	NA	550	25.6	MG/KG		
Beryllium (Be)		4	4	0.1	0.19	0.15	NA	NA	16	0.17	MG/KG		2
Cadmium (Cd)		3	4	0.27	2.8	1.2	0.06	0.06	3.9	0.13	MG/KG		3
Calcium (Ca)		4	4	1580	4370	2540	NA	NA	NA	NA	MG/KG		
Chromium (Cr)		4	4	6.4	9.6	8.2	NA	NA	23	8.4	MG/KG		2
Cobalt (Co)		3	4	0.61	1.6	0.99	0.77	0.77	470	0.34	MG/KG		3
Copper (Cu)		4	4	3.5	13.5	6.45	NA	NA	310	3.86	MG/KG		1
Iron (Fe)		4	4	2000	5000	3700	NA	NA	2300	7060	MG/KG	3	
Lead (Pb)		4	4	9.7	45.8	24.3	NA	NA	400	39.6	MG/KG		1
Magnesium (Mg)		4	4	219	374	213.2	NA	NA	NA	NA	MG/KG		
Manganese (Mn)		4	4	11.3	30.2	18.7	NA	NA	1100	26.4	MG/KG		1
Nickel (Ni)		4	4	1.9	3.8	3	NA	NA	160	1.7	MG/KG		4
Potassium (K)		4	4	141	318	204	NA	NA	NA	NA	MG/KG		
Selenium (Se)		2	4	0.36	0.39	0.375	0.28	0.42	39	0.84	MG/KG		
Sodium (Na)		4	4	44.5	298	196	NA	NA	NA	NA	MG/KG		
Tin (Sn)		2	4	1.1	2.7	1.9	0.52	10.8	4700	19.4	MG/KG		
Vanadium (V)		4	4	7.3	14.5	10.2	NA	NA	55	15.8	MG/KG		
Zinc (Zn)		4	4	21	538	182	NA	NA	2300	14.8	MG/KG		4
Pesticides/PCBs													
Aroclor-1260	*	2	9	106	1780	943	13.65	19.2	320	NA	UG/KG	1	
4,4'-DDD		2	6	4.75	5.71	5.23	1.835	3.7	2700	NA	UG/KG		
4,4'-DDE		6	6	4.65	29.1	17.8408	NA	NA	1900	NA	UG/KG		
4,4'-DDT		5	5	9.62	60.5	28.9	NA	NA	1900	NA	UG/KG		
alpha-Chlordane		1	6	2.06	2.06	2.06	0.945	1.905	1800	NA	UG/KG		
Dieldrin		1	6	26.8	26.8	26.8	1.835	1.92	40	NA	UG/KG		
Endosulfan II		1	6	64.8	64.8	64.8	1.835	1.92	47000	NA	UG/KG		
Endosulfan sulfate		1	6	28.1	28.1	28.1	1.835	1.92	47000	NA	UG/KG		
Endrin aldehyde		1	6	82.8	82.8	82.8	1.835	1.92	2300	NA	UG/KG		
gamma-Chlordane		1	6	20.5	20.5	20.5	0.945	0.99	1800	NA	UG/KG		
Heptachlor epoxide		1	6	16.8	16.8	16.8	0.945	0.99	70	NA	UG/KG		

Notes:
* - Indicates chemical was identified as a COPC
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/KG - micrograms per kilogram
NG/KG - nanograms per kilogram
MG/KG - milligrams per kilogram
NA - Not applicable or not available
a - Reported soil concentrations of dioxin (as TEQs) were compared to the project screening level.

Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact. Therefore, future worker assessment is considered to conservatively represent current site users. The future site resident scenario was built on the premise that existing buildings would be removed and replaced with dwellings.

Exposure Pathways

Exposure pathways for the hypothetical future site residents and site workers are dermal contact and incidental ingestion of surface soils. The exposure pathways for current site workers are the same as those for the future site worker. Uniform exposure was assumed for all sample locations. Table 10.8.8 presents the justification for exposure pathways assessed in this HHRA.

Table 10.8.8
Exposure Pathways Summary — AOC 696
CNC — Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Site Workers	Air, inhalation of gaseous contaminants emanating from soil	No	No COPCs were identified for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Fate and transport did not identify any COPCs for this indirect exposure pathway.
	Shallow groundwater, inhalation of volatilized shallow groundwater contaminants	No	No COPCs were identified for this indirect exposure pathway.
	Soil, incidental ingestion	No (Qualified)	Future site use was considered conservatively representative of current site use.
	Soil, dermal contact	No (Qualified)	Future site use was considered conservatively representative of current site use.

Table 10.8.8
Exposure Pathways Summary — AOC 696
CNC — Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Uses			
Future Site Residents (Child and Adult), Future Site Worker	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Fate and transport did not identify any COPCs for this indirect exposure pathway.
	Shallow groundwater, inhalation of volatilized contaminants during domestic use	No	No COPCs were identified for this indirect exposure pathway.
	Soil, incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, city limits.
	Fruits and vegetables, ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

The maximum detected concentrations were used as exposure point concentrations since fewer than 10 data points were available for each COPC identified. An FI/FC term was applied to the EPC for Aroclor-1260 to account for the limited extent of impact to the surface soil. The FI/FC term is based on the area of Aroclor-1260 impact in relation to a one quarter-acre residential lot. The area of Aroclor-1260 impact was conservatively estimated to be 2,500 square feet, which is approximately two -tenths of one quarter-acre. Accordingly 0.2 was used as the FI/FC to adjust the soil EPC for Aroclor-1260.

Quantification of Exposure

CDIs for ingestion and dermal contact with soils are listed in Tables 10.8.9 and 10.8.10, respectively.

10.8.4.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.8.11 presents toxicological information specific to each COPC identified at AOC 696. This information was used in the quantification of risk/hazard associated with soil contaminants. Each COPC's toxicology is briefly profiled in the following paragraphs.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.0003 mg/kg/day as the RfD for arsenic. As listed in IRIS, the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg/day)^{-1}$ SF. As listed in IRIS, the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic.

Table 10.8.9
Chronic Daily Intakes
Incidental Ingestion of Surface Soil
AOC 696
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganic							
Arsenic (As)	1	5.4	7.4E-06	6.9E-05	8.5E-06	2.6E-06	9.4E-07
PCBs							
Aroclor-1260	0.2	1.78	4.9E-07	4.6E-06	5.6E-07	1.7E-07	6.2E-08

NOTES:

LWA	Lifetime-weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B.
CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.8.10
Chronic Daily Intakes
Dermal Contact with Surface Soil
AOC 696
Charleston Naval Comples, Zone K
Charleston, South Carolina

Chemical	FI/FC *	Exposure Point Concentration (mg/kg)	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganic								
Arsenic (As)	1	5.4	0.001	3.0E-07	1.0E-06	1.9E-07	2.2E-07	7.7E-08
PCBs								
Aroclor-1260	0.2	1.78	0.01	2.0E-07	6.6E-07	1.3E-07	1.4E-07	5.1E-08

NOTES:

CDI	Chronic Daily Intake in mg/kg-day
H-CDI	CDI for hazard quotient
C-CDI	CDI for excess cancer risk
*	Reflects the estimated fraction of the site impacted by the corresponding COPC.
-	The dermal absorption factor was applied to the exposure point concentration to reflect the ability for trans-dermal migration of inorganic and organic chemicals

Table 10.8.11
Toxicological Reference Information
for Chemicals of Potential Concern
AOC 696
Charleston Naval Complex, Zone K
Charleston, South Carolina

	Non-Carcinogenic Toxicity Data									*Carcinogenic Toxicity Data*					
Chemical	**Oral Reference Dose (mg/kg-day)**		**Confidence Level**	**Critical Effect**	**Uncertainty Factor Oral**	**Inhalation Reference Dose (mg/kg-day)**	**Confidence Level**	**Critical Effect**	**Uncertainty Factor Inhalation**	**Oral Slope Factor (kg-day/mg)**		**Inhalation Slope Factor (kg-day/mg)**		**Weight of Evidence**	**Tumor Type**
Arsenic	0.0003	a	M	hyperpigmentation	3	NA	NA	NA	NA	1.5	a	15.1	a	A	various
PCB Aroclor-1260 (soil)	NA		NA	NA	NA	NA	NA	NA	NA	2	a	NA		B2	hepatocellular carcinoma

Notes:

a = Integrated Risk Information System (IRIS)
A = Known human carcinogen
B2 = Possible human carcinogen based on laboratory annimal study data.
NA = Not applicable or not available
L = Low confidence
M = Medium confidence

PCB Aroclors are a group of chlorinated hydrocarbons (such as ***Aroclors-1248, 1254, and 1260***) that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme levels, rashes and chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ (Klaassen, et al., 1986) (Dreisbach, et al., 1987). USEPA classified PCB Aroclors as group B2 probable human carcinogens, primarily based on animal data. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. The cancer potency of PCB mixtures is determined using a tiered approach. The high risk and persistence tier uses an upper-bound slope factor of 2.0 $(mg/kg\text{-}day)^{-1}$ and is appropriate for food chain exposures, sediment and soil ingestion, dust or aerosol inhalation, and dermal exposure. The low risk and persistence tier uses an upper-bound slope factor of 0.4 $(mg/kg\text{-}day)^{-1}$ and is appropriate for ingestion of water-soluble congeners and inhalation of evaporated congeners. The lowest risk and persistence tier uses an upper-bound slope factor of 0.07 $(mg/kf\text{-}day)^{-1}$ and is appropriate for PCB congener mixtures with congeners having more than four chlorines comprising less than 0.5% of the mixture.

10.8.4.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under residential and industrial (site worker) scenarios. For these scenarios, the incidental ingestion and dermal contact exposure pathways were evaluated. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.8.12 and 10.8.13 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of site surface soils, and dermal contact with them.

Table 10.8.12
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 696
Charleston Naval Comples, Zone K
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganic							
Arsenic (As)	0.0003	1.5	0.025	0.23	1.3E-05	0.0088	1.4E-06
PCBs							
Aroclor-1260	NA	2	ND	ND	1.1E-06	ND	1.2E-07
SUM Hazard Index/ILCR			0.02	0.2	1E-05	0.009	2E-06

NOTES:
NA Not available
ND Not Determined due to lack of available information
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk

Table 10.8.13
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 696
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganic								
Arsenic (As)	0.2	0.000	7.5	0.0051	0.017	1.4E-06	0.0036	5.8E-07
PCBs								
Aroclor-1260	0.5	NA	4.0	ND	ND	5.0E-07	ND	2.0E-07
SUM Hazard Index/ILCR				0.005	0.02	2E-06	0.004	8E-07

NOTES:

NA Not available

ND Not Determined due to lack of available information

LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.

ILCR Incremental Lifetime Cancer Risk

- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Hypothetical Site Residents

The ingestion ILCR (based on the adult and child lifetime-weighted average) for AOC 696 surface soils is 1E-5. The dermal pathway ILCR is 2E-6. Arsenic was the primary contributor and Aroclor-1260 was a secondary contributor to ILCR projections for the ingestion and dermal pathways.

The ingestion HIs projected for the adult and child receptors are 0.02 and 0.2, respectively. The dermal pathway HIs were 0.005 for the adult resident receptor and 0.02 for the child resident receptor.

Hypothetical Site Workers

Site worker ILCRs are 2E-6 for the ingestion pathway and 8E-7 for the dermal contact pathway. Arsenic was the primary contributor for the ingestion pathway.

Site worker HIs are 0.009 for the ingestion pathway and 0.004 for the dermal pathway.

COCs Identified

Chemicals of concern were based on cumulative (all pathway) risk and hazard projected for this site on a medium-specific basis. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). As recommended by SCDHEC, a COC was considered to be any chemical contributing to a cumulative risk level of at least 1E-6 and/or a cumulative hazard index exceeding 1.0, if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to more comprehensively evaluate chemicals contributing to carcinogenic risk or noncarcinogenic hazard during development of remedial goal options. Table 10.8.14 summarizes the COCs identified for AOC 696 surface soil.

Future Site Residents

Arsenic and Aroclor-1260 were identified as soil pathway COCs based on their contribution to cumulative residential ILCR projections.

Future Site Workers

Arsenic was identified as the only soil pathway COC based on its contribution to cumulative industrial ILCR projections.

The extent of the COCs identified in surface soil is briefly discussed below. To facilitate this discussion of the extent of the COCs, residential soil RBCs were compared to each reported COC concentration. Arsenic exceeded its RBC in all four surface soil samples for which it was analyzed and marginally exceeded its background reference concentration in three out of four samples. Aroclor-1260 exceeded its RBC in a sample from only one surface soil location (696SB003).

10.8.4.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Table 10.8.14
Summary of Risk and Hazard-based COCs
AOC 696
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient (HI)	Future Resident Child Hazard Quotient (HI)	Future Resident LWA ILCR	Current Site Worker Hazard Quotient	Current Site Worker ILCR	Identification of COCs	
Surface Soil	Incidental	**Inorganic**							
	Ingestion	Arsenic (As)	0.025	0.23	1.3E-05	0.009	1.4E-06	2	4
		PCBs							
		Aroclor-1260	ND	ND	1.1E-06	ND	1.2E-07	2	
	Dermal	**Inorganic**							
		Arsenic (As)	0.005	0.017	1.4E-06	0.0036	5.8E-07	2	
		PCBs							
		Aroclor-1260	ND	ND	5.0E-07	ND	2.0E-07		
Surface Soil Pathway Sum			0.03	0.2	2E-05	0.01	2E-06		

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
Identification of COCs
1 - Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2 - Chemical is a COC by virtue of projected future resident lifetime ILCR.
3 - Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.
4 - Chemical is a COC by virtue of projected site worker ILCR.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. If this area were to be used as a residential site, the surface soil conditions would likely change — the soils could be covered with landscaping soil and/or a house. Consequently, exposure to surface soil conditions as represented by samples collected during the CSI would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

Determination of Exposure Point Concentrations

The maximum concentrations of each COPC were used as EPCs since there were too few data to calculate 95% UCLs. Since elevated concentrations of Aroclor-1260 were isolated to a small area, the use of the maximum concentration as its EPC likely causes an overestimation of risk associated with this COPC. As a result, an FI/FC term was applied to adjust the EPC to reflect the limited extent of Aroclor-1260 impacts.

Frequency of Detection and Spatial Distribution

Aroclor-1260 exceeded its risk-based concentrations in only one of nine surface soil samples. The only other detection of Aroclor-1260 was approximately one order of magnitude lower than the highest concentration. The limited extent of Aroclor-1260 impacts warranted the use of an FI/FC term.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

A conservative screening process was used to identify COPCs for AOC 696. The potential for eliminating CPSSs with the potential for cumulative HI greater than 1 was addressed for noncarcinogens through the use of RBCs that were reduced one order of magnitude. For carcinogens, the RBCs are based on a conservative target risk of 1E-06. Combining conservative RBCs with maximum detected concentrations minimizes the likelihood of a significant contribution to risk/hazard based on eliminated CPSSs. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration within 10% of its RBC.

10.8.4.7 Risk Summary

The risk and hazard posed by contaminants at AOC 696 were assessed for future site workers and future site residents under reasonable maximum exposure assumptions. In surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. Table 10.8.15 summarizes risk for each soil pathway/receptor group evaluated for AOC 696.

Soil — Residential Scenario

Residential soil pathway COCs identified for AOC 696 are arsenic and Aroclor-1260. Figure 10.8.3 illustrates point risk estimates for AOC 696 based on surface soil exposure pathways under a future residential scenario. Table 10.8.16 summarizes the risk and hazard contribution of each COPC at each sample location. This point risk map is based on the unlikely assumption that a potential future site resident would be chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of uniform exposure to the soil conditions of the entire site (or exposure unit area) rather than specific points. Risk maps supplemented by the table help the reader to visualize how chemicals driving risk estimates are spatially distributed across the site.

Table 10.8.15
Summary of Risk and Hazard
AOC 696
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.02	0.2	1E-05	0.01	2E-06
	Dermal Contact	0.005	0.02	2E-06	0.004	8E-07
Sum of Soil Pathways		0.03	0.2	2E-05	0.01	2E-06

Notes:
ILCR Indicates incremental lifetime cancer risk
HI Indicates hazard index

Table 10.8.16
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOC 696
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
696	B001	Aroclor-1260	ND	UG/KG	NA		NA	
696	B001	Arsenic (As)	5.4	MG/KG	0.2468	100.00	14.1048	100.00
		Total			0.2468		14.1048	
696	B002	Aroclor-1260	ND	UG/KG	NA		NA	
		Total			NA		NA	
696	B003	Aroclor-1260	1780	UG/KG	NA		8.0760	100.00
		Total			NA		8.0760	
696	B004	Aroclor-1260	106	UG/KG	NA		0.4809	100.00
		Total			NA		0.4809	
696	B005	Aroclor-1260	ND	UG/KG	NA		NA	
		Total			NA		NA	
696	B006	Aroclor-1260	ND	UG/KG	NA		NA	
		Total			NA		NA	
696	B007	Aroclor-1260	ND	UG/KG	NA		NA	
		Total			NA		NA	
696	B008	Aroclor-1260	ND	UG/KG	NA		NA	
		Total			NA		NA	
696	B009	Aroclor-1260	ND	UG/KG	NA		NA	
		Total			NA		NA	
696	B010	Arsenic (As)	3.5	MG/KG	0.1600	100.00	9.1420	100.00
		Total			0.1600		9.1420	
696	B011	Arsenic (As)	4.4	MG/KG	0.2011	100.00	11.4928	100.00
		Total			0.2011		11.4928	
696	B012	Arsenic (As)	2.7	MG/KG	0.1234	100.00	7.0524	100.00
		Total			0.1234		7.0524	

LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

20 0 20 40 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.8.3
AOC 696

POINT RISK ESTIMATES FOR
SURFACE SOIL
RESIDENTIAL SCENARIO

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Arsenic contributed to risk estimates exceeding 1E-06 in each of the four soil locations for which there was an analysis. Aroclor-1260 contributes to risk estimates exceeding 1E-06 at one location (696SB003). Risk estimates ranged from 5E-07 (696SB004) to 1E-05 (696SB001) with a mean risk estimate of 4E-06 (assuming a de minimus risk of 1E-07 for surface soil sample with no reported concentrations of carcinogenic COCPs).

Soil — Site Worker Scenario

Arsenic was the only site worker soil pathway COC identified for AOC 696. Figure 10.8.4 illustrates point risk estimates for AOC 696 based on surface soil exposure pathways under a site worker scenario. As shown on Table 10.8.17, soil arsenic concentrations were associated with risks ranging from 1E-06 to 2E-06.

10.8.4.8 Remedial Goal Options

RGOs for carcinogens were based on the lifetime-weighted average site resident or site worker as presented in Table 10.8.18 for surface soils. Hazard-based RGOs were based on the hypothetical child resident or site worker, as noted in the table.

10.8.5 Corrective Measures Considerations

For AOC 696, 12 upper-interval and nine lower-interval soil samples were collected. Based on the analytical results and the human health risk assessment, COCs requiring further evaluation through the CMS process were identified for the upper-soil interval.

Arsenic and Arochlor-1260 were identified as COCs in the upper soil interval detected concentrations of both exceeded their residential RBCs. The soil pathway cumulative residential exposure risk is 2E-05 and the cumulative HI is 0.2 (resident child). Both are between USEPA's acceptable range of 1E-06 and 1E-04 for risk and 3 and 0.1 for HI.

Table 10.8.17
Point Estimates of Risk and Hazard - Surface Soil Pathways
Industrial Scenario
AOC 696
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
696	B001	Arsenic (As)	5.4	MG/KG	0.0124	100.00	1.9953	100.00
		Total			0.0124		1.9953	
696	B010	Arsenic (As)	3.5	MG/KG	0.0080	100.00	1.2933	100.00
		Total			0.0080		1.2933	
696	B011	Arsenic (As)	4.4	MG/KG	0.0101	100.00	1.6258	100.00
		Total			0.0101		1.6258	
696	B012	Arsenic (As)	2.7	MG/KG	0.0062	100.00	0.9977	100.00
		Total			0.0062		0.9977	

LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

20 0 20 40 Feet

ZONE K - RCRA
FACILITY INVESTIGATION
NAVAL BASE CHARLESTON
CHARLESTON, SC

FIGURE 10.8.4
AOC 696

POINT RISK ESTIMATES FOR
SURFACE SOIL
INDUSTRIAL SCENARIO

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Table 10.8.18
Remedial Goal Options for Soil
AOC 696
Charleston Naval Complex, Zone K
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Inorganic										
Arsenic (As)	1.5	0.0003	5.4	66	22	2.2	0.38	3.8	38	3
PCBs										
Aroclor-1260	2	NA	1.8	NA	NA	NA	1.1	11	110	3

Worker-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Inorganic										
Arsenic (As)	1.5	0.0003	5.4	1305	435	43	2.7	27	271	3

NOTES:
EPC Exposure point concentration
NA Not applicable
- Remedial goal options were based on the residential or site worker lifetime weighted average for carcinogens and the child resident or site worker for noncarcinogens

The residential risk-based remedial goal for surface soil set for arsenic was 0.38, based on a target risk of 1E-06. Potential corrective measures and COCs are presented in Table 10.8.19.

Table 10.8.19
Potential Corrective Measures for AOC 696

Medium	Compounds	Potential Corrective Measures
Soil	Arsenic and Arochlor-1260	a) No Action b) Intrinsic remediation and monitoring c) Containment by capping d) Excavation and landfill, if RCRA-nonhazardous waste e) Insitu, chemical and physical treatment f) Exsitu, chemical and physical treatment

10.9 AOC 698, Building 2508, Boiler House, Naval Annex

AOC 698, Building 2508 at Naval Annex (Figure 10.9.1), houses four boilers that once supplied steam to various annex facilities. Completed in 1955, the building was originally operated by the Air Force. In 1981, the Navy assumed ownership of the building, which has been out of service for several years and is in poor condition. The building is designated as an AOC due to lead-based paint that is peeling off interior and exterior surfaces. Paint chips that have fallen to the ground are subject to decomposition by weather and human activities such as grass cutting. As the size of the chip decreases by decomoposition, surface area increases, which in turn increases the oxidation potential. As lead-based paint oxidizes, a readily leachable lead-containing powder forms that will migrate to soil and may percolate through the soil into the groundwater.

A 10,000-gallon fuel oil aboveground storage tank was formerly located on the northeast side of Building 2508. Original project plans indicate that the AST had been present since Building 2508 was constructed. A cinder block secondary containment berm was added in the late 1970s. The containment berm and concrete tank supports are still present, although the tank was removed in the mid-1990s. What appears to be disturbed soil was observed immediately north of the AST containment berm. Stained soil was observed in the immediate area of the smoke stack on the west side of Building 2508.

Materials of concern identified in the final RFI work plan (E/A&H, September 1996) for AOC 698 are lead and petroleum hydrocarbons. Potential receptors are current and future site users involved in excavation activities.

To fulfill RFI objectives, soil was sampled in accordance with the final RFI work plan and as described in Section 3 of this report to confirm whether any contamination resulted from onsite activities at AOC 698.

10.9.1 Soil Sampling and Analysis

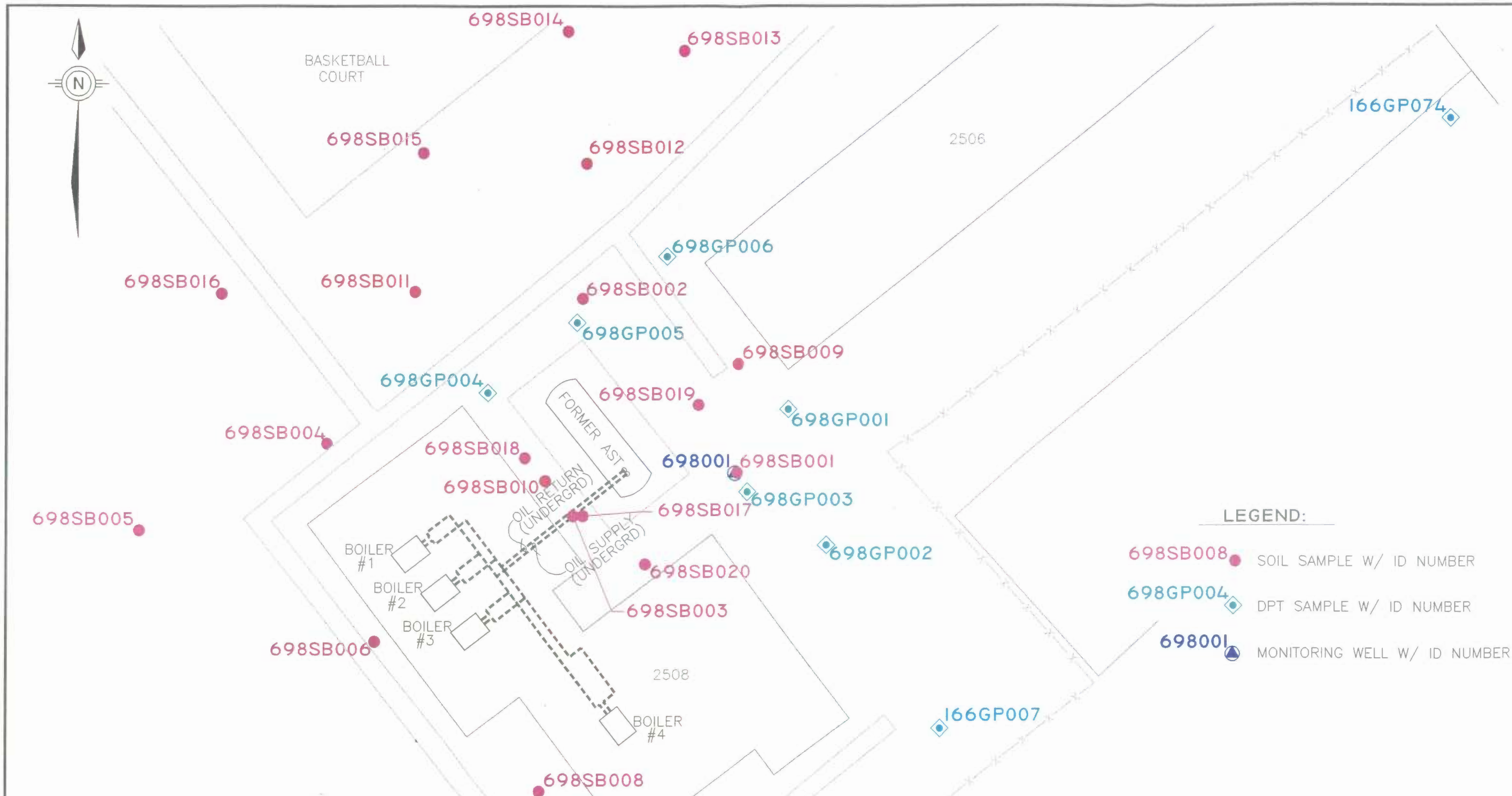
Three soil sampling rounds were performed at AOC 698 from the locations shown on Figure 10.9.1. The final RFI work plan proposed collection of eight soil samples from the upper-interval (0 to 1 foot) and eight from the lower-interval (3 to 5 feet) for the AOC 698 investigation area. All of the originally proposed samples were collected during first-round soil sampling in December 1996.

Round one soil samples were submitted for analysis at DQO Level III for VOCs, SVOCs, and metals. One duplicate was collected from boring 698SB002's upper-interval and submitted for Appendix IX analyses at DQO Level IV. During a second sampling round in February 1998, four additional upper-interval samples were collected and submitted at DQO Level III for pesticide analysis only. January 1999 (round three samples) from borings 698SB013 through 016 were submitted at DQO Level III for pesticides; those from borings 698SB017 through 020 were submitted for VOC and SVOC analysis. An additional duplicate was collected during round three from boring 698SB020's upper-interval and submitted for VOC and SVOC analysis only. Table 10.9.1 summarizes soil sampling for AOC 698.

Table 10.9.1
AOC 698
Soil Sampling Summary

Sampling Round	Sampling Date	Samples Collected	Sample Analyses	Comments
1	12/3/96	Upper - 8 (8) Lower - 8 (8) Duplicate - 1	VOCs, SVOCs, and metals	None
2	2/26/98	Upper - 4 (0)	Pesticides	None
3	1/23/99	Upper - 8 (0) Lower - 8 (0)	VOCs, SVOCs and pesticides[a,b]	None
		Duplicate - 1	VOCs and SVOCs	

Notes:
( ) = Parentheses indicate the number of samples proposed in the RFI work plan.
a = Samples from borings 698SB013 through 016 received pesticides analysis only.
b = Samples from borings 698SB017 through 020 received VOCs and SVOCs analysis only.



ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.9.1
SITE MAP
AOC 698

Date: 06/02/99 | DWG Name: 2911C059

00149T172

10.9.2 Nature and Extent of Contamination in Soil

Organic compound analytical results for soil are summarized in Table 10.9.2. Inorganic chemical analytical results are summarized in Table 10.9.3. Table 10.9.4 summarizes all analytes detected in soil at AOC 698. Analyte concentrations are listed in bold type it they exceeded their screening concentrations the applicable residential soil RBC or SSL and, when available, the associated background concentration. Appendix F is a complete analytical data report for all samples collected in Zone K, including AOC 698.

Table 10.9.2
AOC 698
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Semivolatile Organic Compounds (μg/kg)						
24 samples collected, 12 upper-interval, 12 lower-interval, and 1 duplicate sample						
BEQs	Upper	2/12	28.06 - 2092.6	1060.3	87	1
	Lower	0/12	ND	ND	4,000	0
Benzo(a)anthracene	Upper	1/12	550	550	870	0
	Lower	0/12	ND	ND	800	0
Benzo(a)pyrene	Upper	1/12	1,300	1,300	87	1
	Lower	0/12	ND	ND	4,000	0
Benzo(b)fluoranthene	Upper	2/12	110 - 1,500	805	870	1
	Lower	0/12	ND	ND	2,300	0
Benzo(k)fluoranthene	Upper	2/12	93 - 1,700	897	8,700	0
	Lower	0/12	ND	ND	25,000	0
Chrysene	Upper	2/12	130 - 600	365	87,000	0
	Lower	0/12	ND	ND	80,000	0
Dibenz(a,h)anthracene	Upper	1/12	410	410	87	1
	Lower	0/12	ND	ND	800	0
Indeno(1,2,3-cd)pyrene	Upper	2/12	160 - 1,600	880	870	1
	Lower	0/12	ND	ND	7,000	0
2-Methylnaphthalene	Upper	2/12	96 - 300	198	160,000	0
	Lower	0/12	ND	ND	18,000	0
Anthracene	Upper	1/12	41	41	2,300,000	0
	Lower	0/12	ND	ND	6,000,000	0
Benzo(g,h,i)perylene	Upper	1/12	1600	1600	160,000	0
	Lower	0/12	ND	ND	57,000,000	0
bis(2-Ethylhexyl)phthalate	Upper	2/12	98 - 120	109	46,000	0
(BEHP)	Lower	0/12	ND	ND	1,800,000	0
Butylbenzylphthalate	Upper	1/12	150	150	1,600,000	0
	Lower	0/12	ND	ND	930,000	0

Table 10.9.2
AOC 698
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
Dibenzofuran	Upper	1/12	100	100	31,000	0
	Lower	0/12	ND	ND	6,800	0
Fluoranthene	Upper	2/12	210 - 320	265	310,000	0
	Lower	0/12	ND	ND	2,100,000	0
Naphthalene	Upper	2/12	55 - 160	108	160,000	0
	Lower	0/12	ND	ND	31,000	0
Phenanthrene	Upper	2/12	90 - 360	225	160,000	0
	Lower	0/12	ND	ND	660,000	0
Phenol	Upper	2/12	100 - 2,100	1,100	4,700,000	0
	Lower	0/12	ND	ND	50,000	0
Pyrene	Upper	2/12	200 - 560	380	230,000	0
	Lower	0/12	ND	ND	2,100,000	0
Pesticides (μg/kg)						
13 samples collected, 9 upper-interval samples, 4 lower-interval samples, and 1 duplicate sample						
4,4'-DDD	Upper	2/9	4.38 - 54	29.2	2,700	0
	Lower	0/4	ND	ND	8,000	0
4,4'-DDE	Upper	8/9	3.3 - 990	139	1,900	0
	Lower	0/4	ND	ND	27,000	0
4,4'-DDT	Upper	9/9	5.4 - 370	65.4	1,900	0
	Lower	0/4	ND	ND	16,000	0
alpha-Chlordane	Upper	4/9	2.6 - 55.2	28.6	1,800	0
	Lower	0/4	ND	ND	5,000	0
Dieldrin	Upper	1/9	6.59	6.59	40	0
	Lower	0/4	ND	ND	2	0
Endosulfan sulfate	Upper	1/9	5.94	5.94	47,000	0
	Lower	0/4	ND	ND	4,600	0
Endrin	Upper	1/9	27	27	2,300	0
	Lower	0/4	ND	NT	500	0
Endrin aldehyde	Upper	1/9	15	15	2,300	0
	Lower	0/4	ND	ND	340	0
Endrin ketone	Upper	2/9	5.2 - 9.79	7.50	2,300	0
	Lower	0/4	ND	ND	340	0
gamma-Chlordane	Upper	6/9	1.7 - 214	50.9	1,800	0
	Lower	0/4	ND	ND	5,000	0
Heptachlor	Upper	1/9	9.5	9.5	140	0
	Lower	0/4	ND	ND	11,000	0
Heptachlor epoxide	Upper	4/9	2.2 - 140	69.4	70	2
	Lower	0/4	ND	ND	330	0

Table 10.9.2
AOC 698
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBC or SSL
TPH-DRO (mg/kg)						
1 upper-interval duplicate sample collected						
Diesel	Upper	1/1	149	149	100[a]	1
	Lower	0/0	NT	NT	100[a]	NA
Dioxins (ng/kg)						
1 upper-interval duplicate for Appendix IX analysis						
TEQ	Upper	1/1	11.92	11.92	4.3	1
	Lower	0/0	NT	NT	1,600	0
1234678-HpCDD	Upper	1/1	306	306	430	0
	Lower	0/0	NT	NT	110,000	0
1234678-HpCDF	Upper	1/1	84	84	430	0
	Lower	0/0	NT	NT	54,000	0
1234789-HpCDF	Upper	1/1	1.92	1.92	430	0
	Lower	0/0	NT	NT	54,000	0
123478-HxCDD	Upper	1/1	2.05	2.05	43	0
	Lower	0/0	NT	NT	4,100	0
123478-HxCDF	Upper	1/1	8.81	8.81	43	0
	Lower	0/0	NT	NT	220,000	0
123678-HxCDD	Upper	1/1	6.91	6.91	43	0
	Lower	0/0	NT	NT	4,100	0
123678-HxCDF	Upper	1/1	4.46	4.46	43	0
	Lower	0/0	NT	NT	220,000	0
123789-HxCDD	Upper	1/1	5.2	5.2	43	0
	Lower	0/0	NT	NT	4,140	0
12378-PeCDF	Upper	1/1	0.926	0.926	85	0
	Lower	0/0	NT	NT	770	0
234678-HxCDF	Upper	1/1	7.2	7.2	43	0
	Lower	0/0	NT	NT	220,000	0
2378-TCDD	Upper	1/1	2.12	2.12	43	0
	Lower	0/0	NT	NT	1,600	0
OCDD	Upper	1/1	2,240	2,240	4,300	0
	Lower	0/0	NT	NT	1,100,000	0
OCDF	Upper	1/1	129	129	4,300	1
	Lower	0/0	NT	NT	540,000	0

Notes:

a = Charleston Naval Complex project screening level
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed
NT = Not taken
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
ng/kg = Nanograms per kilogram

Table 10.9.3
AOC 698
Inorganics Detected in Soil (mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range			Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBCs and Background (upper) or SSL and Background (lower)
Inorganics mg/kg									
20 upper-interval samples and 16 lower-interval samples, 3 duplicates									
Aluminum	Upper	8/8	4,590	-	5,940	5,120	11,200	7,800	0
	Lower	8/8	2,490	-	6,910	4,570	10,500	560,000	0
Antimony	Upper	3/8	0.44	-	0.53	0.49	0.45	3.1	0
	Lower	0/8		ND		NA	***	2.7	NA
Arsenic	Upper	8/8	0.98	-	10.5	4.5	3	0.43[a]	5
	Lower	6/8	0.49	-	3.4	1.2	1.98	15	0
Barium	Upper	8/8	9.9	-	105	28	25.6	550	0
	Lower	8/8	1.8	-	3.6	2.6	6.83	820	0
Beryllium	Upper	4/8	0.06	-	0.65	0.22	0.17	16.0	0
	Lower	0/8		ND		ND	0.12	32	ND
Cadmium	Upper	5/8	0.1	-	4	1	0.13	3.9	1
	Lower	0/8		ND		NA	***	4	ND
Calcium	Upper	8/8	96.5	-	1,450	1,450	NA	NL	NA
	Lower	8/8	19.2	-	327	133	NA	NL	NA
Chromium	Upper	8/8	2.5	-	10.7	4.9	8.4	23	0
	Lower	8/8	1.6	-	6.3	3.4	8.76	19	0
Cobalt	Upper	4/8	0.2	-	2	0.72	0.34	470	0
	Lower	3/8	0.13	-	0.23	0.17	0.62	990	0
Copper	Upper	8/8	0.71	-	30.7	9.0	3.86	310	0
	Lower	3/8	0.25	-	0.45	0.36	0.34	5,600	0
Iron	Upper	8/8	1240	-	7160	2,831	7,060	2,300	1
	Lower	8/8	944	-	4820	2,046	5,130	NL	NA
Lead	Upper	8/8	5.2	-	119	54	39.6	400*	0
	Lower	5/8	2.8	-	3.2	3.1	6.43	400**	0
Magnesium	Upper	8/8	80	-	505	175	NA	NL	NA
	Lower	8/8	26.7	-	62.9	48.3	NA	NL	NA
Manganese	Upper	8/8	5.7	-	70.4	18.9	26.4	160	0
	Lower	8/8	1.6	-	2.8	2.1	5.93	480	0

Table 10.9.3
AOC 698
Inorganics Detected in Soil (mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBCs and Background (upper) or SSL and Background (lower)
Mercury	Upper	4/8	0.06 - 0.16	0.11	***	2.3	0
	Lower	0/8	ND	NA	***	1.0	0
Nickel	Upper	8/8	0.2 - 6.7	1.8	1.7	160	0
	Lower	8/8	0.32 - 2.4	1.0	2.64	65	0
Potassium	Upper	8/8	31 - 192	79	NA	NL	NA
	Lower	8/8	5.9 - 25.6	16.9	NA	NL	NA
Sodium	Upper	8/8	6.4 - 131	31	NA	NL	NA
	Lower	8/8	4.7 - 9.9	8.0	NA	NL	NA
Tin	Upper	1/8	9.8	9.8	19.4	4,700	0
	Lower	1/8	10.4	10.4	NA	5,500	0
Vanadium	Upper	8/8	4.5 - 9.3	7.0	15.8	55	0
	Lower	8/8	3.9 - 16.7	6.4	12.2	3,000	0
Zinc	Upper	7/8	12.5 - 296	129	14.8	2,300	0
	Lower	0/8	ND	NA	***	6,200	0

Notes:
a = Arsenic as a carcinogen.
* = RBC for lead is not listed. USEPA residential soil cleanup level is used for comparison.
** = SSL value not based on target leachate concentration.
*** = Number of nondetects prevented determination of reference concentrations.
NA = Not applicable/not available/not analyzed.
ND = Not detected/not determined.

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Semivolatile Organic Compounds (μg/kg)							
BEQs	698SB019	28.06	87	NA	ND	4,000	NA
	698SB020	**2092.6**			ND		
Benzo(a)anthracene	698SB020	550	870	NA	ND	800	NA
Benzo(a)pyrene	698SB020	**1,300**	87	NA	ND	4,000	NA
Benzo(b)fluoranthene	698SB019	110	870	NA	ND	2,300	NA
	698SB020	**1,500**			ND		
Benzo(k)fluoranthene	698SB019	93	8,700	NA	ND	25,000	NA
	698SB020	1,700			ND		
Chrysene	698SB019	130	87,000	NA	ND	80,000	NA
	698SB020	600			ND		
Dibenz(a,h)anthracene	698SB020	**410**	87	NA	ND	800	NA
Indeno(1,2,3-cd)pyrene	698SB019	160	870	NA	ND	7,000	NA
	698SB020	**1,600**			ND		
2-Methylnaphthalene	698SB019	96	160,000	NA	ND	18,000	NA
	698SB020	300			ND		
Anthracene	698SB020	41	2,300,000	NA	ND	6,000,000	NA
Benzo(g,h,i)perylene	698SB020	1,600	160,000	NA	ND	57,000,000	NA
bis(2-Ethylhexyl)phthalate (BEHP)	698SB019	120	46,000	NA	ND	1,800,000	NA
	698SB020	98			ND		
Butylbenzylphthalate	698SB019	150	1,600,000	NA	ND	930,000	NA
Dibenzofuran	698SB020	100	31,000	NA	ND	6,800	NA

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Fluoranthene	698SB019	210	310,000	NA	ND	2,100,000	NA
	698SB020	320			ND		
Naphthalene	698SB019	55	160,000	NA	ND	31,000	NA
	698SB020	160			ND		
Phenanthrene	698SB019	90	160,000	NA	ND	660,000	NA
	698SB020	360			ND		
Phenol	698SB019	2,100	4,700,000	NA	ND	50,000	NA
	698SB020	100			ND		
Pyrene	698SB019	200	230,000	NA	ND	2,100,000	NA
	698SB020	560			ND		
Pesticides/PCBs (μg/kg)							
4,4-DDD	698CB002	4.38	2,700	NA	ND	8,000	NA
	698SB011	54			ND		
4,4-DDE	698SB009	5.9	1,900	NA	ND	27,000	NA
	698SB010	5.3			ND		
	698SB011	990			ND		
	698SB012	26			ND		
	698SB013	52			ND		
	698SB014	9.6			ND		
	698SB015	16			ND		
	698SB016	3.3			ND		

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
4,4-DDT	698CB002	31.6	1,900	NA	ND	16,000	NA
	698SB009	8.8			ND		
	698SB010	33			ND		
	698SB011	370			ND		
	698SB012	43			ND		
	698SB013	68			ND		
	698SB014	9.8			ND		
	698SB015	19			ND		
	698SB016	5.4			ND		
alpha-Chlordane	698CB002	55.2	1,800	NA	ND	5,000	NA
	698SB010	2.6			ND		
	698SB011	50			ND		
	698SB012	6.4			ND		
Dieldrin	698CB002	6.59	40	NA	NA	2.0	NA
Endosulfan sulfate	698CB002	5.94	47,000	NA	NA	4,600	NA
Endrin	698SB011	27	2,300	NA	NA	500	NA
Endrin aldehyde	698SB011	15	2,300	NA	NA	340	NA
Endrin ketone	698CB002	9.79	2,300	NA	NA	340	NA
	698SB012	5.2			ND		
gamma-Chlordane	698CB002	214	1,800	NA	ND	5,000	NA
	698SB010	1.8			ND		
	698SB011	80			ND		
	698SB012	4.3			ND		
	698SB013	3.3			ND		
	698SB015	1.7			ND		
Heptachlor	698SB011	9.5	140	NA	ND	11,000	NA

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Heptachlor epoxide	698CB002	**129**	70	NA	ND	330	NA
	698SB011	**140**			ND		
	698SB012	2.2			ND		
	698SB013	6.3			ND		
Dioxin Compounds (ng/kg)							
TCDD TEQ	698CB002	**11.92**	4.3	NA	NT	1,600	NA
1234678-HpCDD	698CB002	306	430	NA	NT	110,000	NA
1234678-HpCDF	698CB002	84	430	NA	NT	54,000	NA
1234789-HpCDF	698CB002	1.92	430	NA	NT	54,000	NA
123478-HxCDD	698CB002	2.05	43	NA	NT	4,100	NA
123478-HxCDF	698CB002	8.81	43	NA	NT	220,000	NA
123678-HxCDD	698CB002	6.91	43	NA	NT	4,100	NA
123678-HxCDF	698CB002	4.46	43	NA	NT	220,000	NA
123789-HpCDD	698CB002	5.2	NA	NA	NT	NA	NA
12378-PeCDF	698CB002	0.926	85	NA	NT	770	NA
234678-HxCDF	698CB002	7.2	43	NA	NT	220,000	NA
2378-TCDD	698CB002	2.12	43	NA	NT	1,600	NA
OCDD	698CB002	2,240	4,300	NA	NT	1,100,000	NA
OCDF	698CB002	129	4,300	NA	NT	540,000	NA
TPH-DRO (mg/kg)							
Diesel	698CB002	**149**	100	NA	NT	100	NA

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Inorganics (mg/kg)							
Aluminum (Al)	698SB001	5,390	7,800	11,200	3,630	560,000	10,500
	698SB002	4,590			4,200		
	698SB003	5,280			2,490		
	698SB004	4,800			5,980		
	698SB005	4,620			6,910		
	698SB006	5,450			5,840		
	698SB007	5,940			4,040		
	698SB008	4,890			3,470		
Antimonoy (Sb)	698SB001	0.53	3.1	0.45	ND	2.7	NA
	698SB002	0.44			ND		
	698SB003	0.5			ND		
Arsenic (As)	698SB001	6.7	0.43	3.0	1.5	15	1.98
	698SB002	2.45			0.49		
	698SB003	4.8			0.63		
	698SB004	10.5			ND		
	698SB005	0.98			0.58		
	698SB006	5.4			3.4		
	698SB007	3.5			ND		
	698SB008	1.4			0.76		
Barium (Ba)	698SB001	105	550	25.6	2.6	820	6.83
	698SB002	25.85			2.8		
	698SB003	16			1.8		
	698SB004	24.2			3.6		
	698SB005	11.1			3.4		
	698SB006	18.8			1.8		
	698SB007	11.1			2.6		
	698SB008	9.9			2.2		

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Beryllium (Be)	698SB001	0.65	16	0.17	ND	32	0.12
	698SB002	0.09			ND		
	698SB003	0.06			ND		
	698SB006	0.06			ND		
Cadmium (Cd)	698SB001	0.71	3.9	0.13	ND	4	NA
	698SB002	0.435			ND		
	698SB003	4			ND		
	698SB004	0.1			ND		
	698SB006	0.27			ND		
Calcium (Ca)	698SB001	4,150	NL	NL	126	NL	NA
	698SB002	1,560			108		
	698SB003	1,080			68.7		
	698SB004	1,180			327		
	698SB005	295			19.2		
	698SB006	2,010			89.8		
	698SB007	1,230			115		
	698SB008	96.5			212		
Chromium (Cr)	698SB001	7.5	23	8.4	2.5	19	8.76
	698SB002	4.05			3.1		
	698SB003	10.7			1.6		
	698SB004	3.4			6.3		
	698SB005	2.5			4.3		
	698SB006	4.2			4.2		
	698SB007	3.6			2.7		
	698SB008	3			2.4		

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Cobalt (Co)	698SB001	2	470	0.34	ND	990	0.62
	698SB002	0.24			0.13		
	698SB003	0.45			ND		
	698SB004	ND			0.15		
	698SB005	ND			0.23		
	698SB006	0.2			ND		
Copper (Cu)	698SB001	30.7	310	3.86	ND	5,600	0.34
	698SB002	23.7			0.39		
	698SB003	4.6			ND		
	698SB004	1.8			0.45		
	698SB005	0.71			0.25		
	698SB006	8.7			ND		
	698SB007	0.92			ND		
	698SB008	1			ND		
Iron (Fe)	698SB001	7,160	2,300	7060	3,480	NL	5130
	698SB002	3,150			1,730		
	698SB003	3,040			1,490		
	698SB004	1,300			944		
	698SB005	1,240			1,200		
	698SB006	2,440			4,820		
	698SB007	3,050			1,500		
	698SB008	1,270			1,200		
Lead (Pb)	698SB001	119	400	39.6	3	400	6.43
	698SB002	53.9			ND		
	698SB003	101			3.2		
	698SB004	17.2			2.8		
	698SB005	15			3.1		
	698SB006	113			ND		
	698SB007	8.2			3.2		
	698SB008	5.2			ND		

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Magnesium (Mg)	698SB001	505	NL	NA	61	NL	NA
	698SB002	135.5			51.4		
	698SB003	117			26.7		
	698SB004	80			53.2		
	698SB005	81.2			62.9		
	698SB006	140			39.2		
	698SB007	121			54.8		
	698SB008	222			37		
Manganese (Mn)	698SB001	70.4	160	26.4	2.7	480	5.93
	698SB002	18.75			1.9		
	698SB003	15.7			1.6		
	698SB004	7.7			2		
	698SB005	5.7			2.8		
	698SB006	19.7			1.7		
	698SB007	7.1			2.2		
	698SB008	6.3			1.6		
Mercury (Hg)	698SB001	0.15	2.3	NA	ND	1	NA
	698SB002	0.065			ND		
	698SB003	0.16			ND		
	698SB006	0.06			ND		
Nickel (Ni)	698SB001	6.7	160	1.7	0.66	65	2.64
	698SB002	1.55			1.3		
	698SB003	1.3			0.32		
	698SB004	0.83			1.7		
	698SB005	0.5			2.4		
	698SB006	1.8			0.77		
	698SB007	1.4			0.64		
	698SB008	0.2			0.6		

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Potassium (K)	698SB001	150	NL	NA	15.1	NL	NA
	698SB002	48.35			23.5		
	698SB003	34.6			5.9		
	698SB004	35.8			25.6		
	698SB005	31			21.6		
	698SB006	70.8			7.5		
	698SB007	70.8			18.8		
	698SB008	192			17.4		
Sodium (Na)	698SB001	131	NL	NA	9.4	NL	NA
	698SB002	29.25			6.6		
	698SB003	14.3			9.8		
	698SB004	15			9.6		
	698SB005	7.6			8.3		
	698SB006	29.1			4.7		
	698SB007	15			9.9		
	698SB008	6.4			5.9		
Tin (Sn)	698CB002	9.8	4,700	19.4	ND	5,500	NA
	698SB005	ND			10.4		
Vanadium (V)	698SB001	9.3	55	15.8	4.9	3,000	12.2
	698SB002	7.65			6.3		
	698SB003	7.8			3.9		
	698SB004	5.5			4.5		
	698SB005	5.4			5.3		
	698SB006	6.9			16.7		
	698SB007	9.1			5.1		
	698SB008	4.5			4.2		

Table 10.9.4
AOC 698
Analytes Detected in Surface and Subsurface Soil

Parameter	Location	Surface Conc.	Residential RBC (THQ=0.1)	Surface Background	Subsurface Conc.	Soil-to-Groundwater SSL (DAF=10)	Subsurface Background
Zinc (Zn)	698SB001	196	2,300	14.8	ND	6,200	NA
	698SB002	147			ND		
	698SB003	181			ND		
	698SB004	32.1			ND		
	698SB005	12.5			ND		
	698SB006	296			ND		
	698SB008	35.2			ND		

Notes:
Bold concentrations exceed the RBCs, SSL, and the zone background.
All background values for Zone K are based on twice the means of the grid sample concentrations.

DAF	=	Dilution attenuation factor
NA	=	Not applicable/not available/not analyzed
ND	=	Not detected/not determined
NL	=	Not listed
NT	=	Not taken
RBC	=	Risk-based concentration
SSL	=	Soil screening level
THQ	=	Target hazard quotient
μg/kg	=	Micrograms per kilogram
mg/kg	=	Milligrams per kilogram

Volatile Organic Compounds in Soil

No VOCs were detected in soil at AOC 698.

Semivolatile Organic Compounds in Soil

Eighteen SVOCs, including several PAHs, were detected in AOC 698 soil samples. All SVOCs were detected in upper-interval samples from locations 698SB019 and 020. In the 698SB020 sample, several PAHs exceeded their RBC: benzo(a)pyrene, benzo(b)fluroanthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd) pyrene. The BEQ calculated for location 698SB020's surface interval, (2,092.6 μg/kg) exceeded the 87 μg/kg RBC. No SVOC exceedances were detected at any other location.

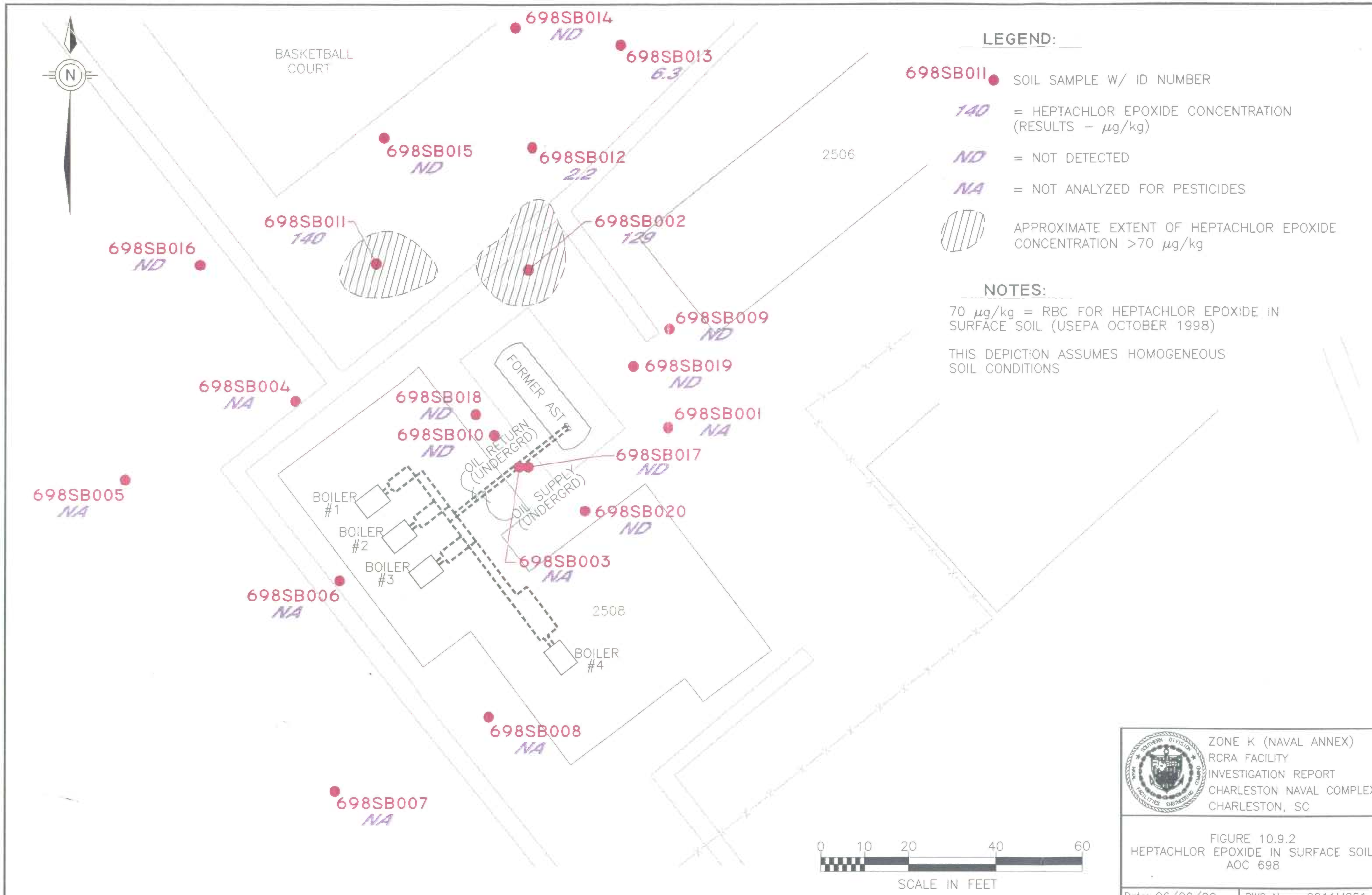
Pesticides/PCBs in Soil

Eleven pesticides were detected in the soil samples collected at AOC 698, specifically the round one duplicate (698CB00201) and several round two samples, all in the upper sample interval. Of the pesticide compounds detected, only heptachlor epoxide exceeded its RBC and it did so only at locations 698SB002 and 011. Figure 10.9.2 shows heptachlor epoxide concentrations that exceeded RBCs in surface soil.

Other Organic Compounds in Soil

Several dioxin congeners were detected in the duplicate sample collected at AOC 698. All individual congener concentrations were below their RBCs. However, the calculated TEQ for this sample (11.92 ng/kg) exceeded the 4.3 ng/kg RBC for 2, 3, 7, 8-TCDD.

TPH-DRO was detected in the duplicate sample at a concentration of 149 mg/kg, which exceeds the project screening level of 100 mg/kg.



ZONE K (NAVAL ANNEX)
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.9.2
HEPTACHLOR EPOXIDE IN SURFACE SOIL
AOC 698

Date: 06/02/99 | DWG Name: 2911M081

00149TB18Z

Inorganics in Soil

Arsenic, cadmium, and iron were detected in soil at concentrations exceeding both their applicable RBC and background concentrations. Although several arsenic exceedances were observed, cadmium and iron exceeded their RBC only once each. The single cadmium and iron exceedances were 4.0 mg/kg at location 698SB003 and 7,160 mg/kg at 698SB001, respectively, both surface exceedances within one order of magnitude of the RBC. Figure 10.9.3 shows arsenic concentrations in surface soil.

10.9.3 Groundwater Sampling and Analysis

The final RFI work plan proposed the installation of one shallow monitoring well for AOC 698. This well (NBCK698001) was installed adjacent to an aboveground fuel oil storage tank.

NBCK698001 was developed in December 1996, and the first-round of groundwater samples were collected in January 1997. Groundwater was analyzed for VOCs, SVOCs, metals, pesticides, and PCBs at DQO Level III.

The analytical data for the first-round sample from NBCK698001 indicated the presence of petroleum hydrocarbons. Six groundwater screening samples were collected around the monitoring well and aboveground storage tank as a result of the first-round monitoring well data. These samples were analyzed for VOCs and TPH.

Second round sampling analytical parameters for AOC 698 were also analyzed for VOCs, SVOCs, metals, pesticides, and PCBs at DQO Level III. Second round samples were collected by the CEERD in April 1997. Third and fourth round groundwater samples were collected in July and October 1997, respectively, and analyzed for the same parameter group (with the addition of TPH during round four). Table 10.9.5 summarizes groundwater sampling at AOC 698.

Table 10.9.5
AOC 698
Groundwater Sampling Summary

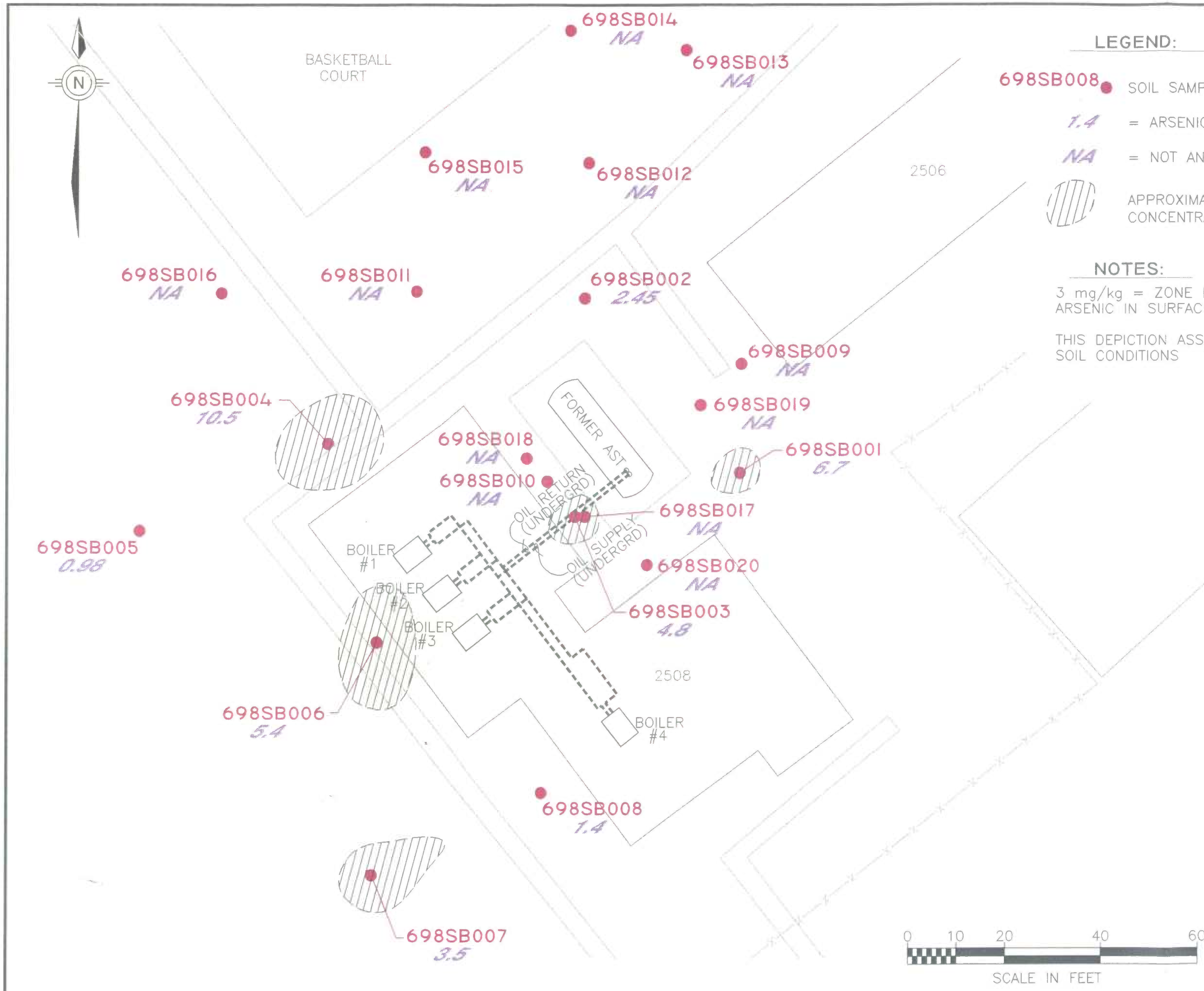
Sampling Round	Sampling Date	Wells Sampled	Sample Analyses	Comments
1	1/6/97	698001	Standard suite and TPH	Six groundwater screening samples were collected following organic compound detections in monitoring well.
	2/28/97	698GP001 698GP002ª 698GP003 698GP004 698GP005 698GP006	VOCs and TPH	
2	4/18/97	698001	Standard suite and TPH	None
3	7/25/97	698001	Standard suite	None
4	10/23/97	698001	Standard suite and TPH	None

Notes:
a = Duplicate sample was collected and analyzed for the same parameters.
Standard suite = VOCs, SVOCs, metals, cyanide, pesticides and PCBs.

The shallow monitoring well was installed at 15 feet bgs in the water table aquifer and as described in Section 3.3 of this report. The screening samples were collected at approximately 10 feet bgs and as described in Section 3.2.6 of this report.

10.9.4 Nature and Extent of Contamination in Groundwater

Table 10.9.6 summarizes organic groundwater analytical results and Table 10.9.7 summarizes groundwater inorganic analytical results for AOC 698. Table 10.9.8 summarizes all analytes detected in groundwater at AOC 698. Analyte concentrations are listed in bold type if they exceeded their screening concentrations, the lower of the applicable tap-water RBC or MCL and, when available, the associated shallow groundwater background concentration. Appendix F is a complete analytical data report for all samples collected in Zone K, including those collected at AOC 698.



LEGEND:

698SB008 ● SOIL SAMPLE W/ ID NUMBER

1.4 = ARSENIC CONCENTRATION (RESULTS – mg/kg)

NA = NOT ANALYZED FOR INORGANICS

APPROXIMATE EXTENT OF ARSENIC CONCENTRATION >3 mg/kg

NOTES:

3 mg/kg = ZONE K BACKGROUND CONCENTRATION FOR ARSENIC IN SURFACE SOIL

THIS DEPICTION ASSUMES HOMOGENEOUS SOIL CONDITIONS

ZONE K (NAVAL ANNEX)
RCRA FACILITY INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.9.3
ARSENIC IN SURFACE SOIL
AOC 698

Date: 06/02/99 | DWG Name: 2911M080

Table 10.9.6
AOC 698
Organics Detected in Groundwater (µg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/MCL	Shallow Background	Number of Samples Exceeding RBC or MCL
Volatile Organic Compounds							
2-Butanone (MEK)	First	0/1	ND	ND	190/NL	NA	0
	Second	0/1	ND	ND		NA	0
	Third	0/1	ND	ND		NA	0
	Fourth	1/1	2.0	2.0		NA	0
Benzene	First	1/1	5	5	0.36/5	NA	0
	Second	1/1	16	16		NA	1
	Third	1/1	7	7		NA	1
	Fourth	1/1	6	6		NA	1
Ethylbenzene	First	1/1	12.0	12.0	130/700	NA	0
	Second	1/1	26.0	26.0		NA	0
	Third	1/1	9.0	9.0		NA	0
	Fourth	1/1	9.0	9.0		NA	0
Toluene	First	1/1	3.0	3.0	75/1,000	NA	0
	Second	1/1	3.0	3.0		NA	0
	Third	0/1	ND	ND		NA	0
	Fourth	0/1	ND	ND		NA	0
Xylene	First	1/1	15	15		NA	0
	Second	1/1	59.0	59.0	1,200/10,000	NA	0
	Third	0/1	ND	ND		NA	0
	Fourth	1/1	18.0	18.0		NA	0
Semivolatile Organic Compounds							
2-Methylnaphthalene	First	1/1	26.0	26.0	12/NL	NA	1
	Second	1/1	29.0	29.0		NA	1
	Third	1/1	9.0	9.0		NA	0
	Fourth	1/1	11.0	11.0		NA	0
4-Methylphenol (p-Cresol)	First	0/1	ND	ND	18/NL	NA	0
	Second	0/1	ND	ND		NA	0
	Third	1/1	4.0	4.0		NA	0
	Fourth	1/1	2.0	2.0		NA	0
Carbazole	First	0/1	ND	ND	3.3/NL	NA	0
	Second	1/1	1.0	1.0		NA	0
	Third	0/1	ND	ND		NA	0
	Fourth	0/1	ND	ND		NA	0
Fluorene	First	0/1	ND	ND	150/NL	NA	0
	Second	1/1	3.0	3.0		NA	0
	Third	0/1	ND	ND		NA	0
	Fourth	0/1	ND	ND		NA	0
Naphthalene	First	1/1	37.0	37.0	73/NL	NA	0
	Second	1/1	27.0	27.0		NA	0
	Third	1/1	12.0	12.0		NA	0
	Fourth	1/1	20.0	20.0		NA	0

Table 10.9.6
AOC 698
Organics Detected in Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/MCL	Shallow Background	Number of Samples Exceeding RBC or MCL
Pesticide and PCB Compounds							
alpha-BHC	First	0/1	ND	ND	.01/NL	NA	0
	Second	0/1	ND	ND		NA	0
	Third	0/1	ND	ND		NA	0
	Fourth	1/1	**.15**	**.15**		NA	1
delta-BHC	First	1/1	**0.21**	**0.21**	0.037/NL	NA	1
	Second	0/1	ND	ND		NA	0
	Third	0/1	ND	ND		NA	0
	Fourth	0/1	ND	ND		NA	0
Endosulfan II	First	1/1	0.21	0.21	22/NL	NA	0
	Second	0/1	ND	ND		NA	0
	Third	0/1	ND	ND		NA	0
	Fourth	0/1	ND	ND		NA	0
TPH Compounds							
Diesel	First	1/1	6,020	6,020	NL/NL	NA	NA
	Second	1/1	6,400	6,400		NA	NA
	Third	0/1	ND	ND		NA	NA
	Fourth	0/1	ND	ND		NA	NA
Gasoline	First	1/1	450	450	NL/NL	NA	NA
	Second	0/1	500	500		NA	NA
	Third	0/1	ND	ND		NA	NA
	Fourth	1/1	170	170		NA	NA

Notes:
Bold concentrations exceed lower of RBC or MCL.

NA	=	Not applicable/not available/not analyze
NL	=	Not listed
ND	=	Not detected/not determined
μg/L	=	Micrograms per liter

Table 10.9.7
AOC 698
Inorganics Detected in Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Shallow Groundwater Background	Tap-water RBC/ MCL	Number of Samples Exceeding Lower of RBC or MCL and Background
Barium	First	1/1	16.8	16.8	31.2	260/2,000	0
	Second	1/1	13.5	13.5			0
	Third	1/1	16.9	16.9			0
	Fourth	1/1	14.5	14.5			0
Calcium	First	1/1	31,500	31.500	NA	NA/NL	NA
	Second	1/1	44,900	44,900			NA
	Third	1/1	35,300	35,300			NA
	Fourth	1/1	30,800	30,800			NA
Iron	First	1/1	119	119	235	1,100/300	0
	Second	0/1	ND	ND			0
	Third	1/1	13,200	13,200			1
	Fourth	1/1	10,900	10,900			1
Lead	First	0/1	ND	ND	1.94	NL/15	0
	Second	0/1	ND	ND			0
	Third	1/1	3.30	3.30			0
	Fourth	0/1	ND	ND			0
Magnesium	First	1/1	1,670	1,670	NA	NA/NL	NA
	Second	1/1	695	695			NA
	Third	1/1	2,400	2,400			NA
	Fourth	1/1	1,980	1,980			NA
Manganese	First	1/1	19.2	19.2	9.33	73/50	0
	Second	0/1	ND	ND			0
	Third	1/1	29.1	29.1			0
	Fourth	1/1	20.6	20.6			0
Potassium	First	1/1	3,130	3,130	NA	NA/NL	NA
	Second	1/1	3,000	3,000			NA
	Third	1/1	2,490	2,490			NA
	Fourth	1/1	2,530	2,530			NA
Selenium	First	1/1	2.40	2.40	NA	18/50	0
	Second	0/1	ND	ND			0
	Third	0/1	ND	ND			0
	Fourth	0/1	ND	ND			0
Sodium	First	1/1	5,540	5,540	NA	NA/NL	NA
	Second	0/1	ND	ND			NA
	Third	1/1	4 880	4 880			NA
	Fourth	0/1	ND	ND			NA
Vanadium	First	1/1	1.0	1.0	0.80	26/NL	0
	Second	0/1	ND	ND			0
	Third	1/1	1.8	1.8			0
	Fourth	1/1	0.9	0.9			0

Table 10.9.7
AOC 698
Inorganics Detected in Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Shallow Groundwater Background	Tap-water RBC/ MCL	Number of Samples Exceeding Lower of RBC or MCL and Background
Zinc	First	0/1	ND	ND	NA	1,100/5,000	0
	Second	0/1	ND	ND			0
	Third	1/1	24.5	24.5			0
	Fourth	0/1	ND	ND			0

Notes:
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed

Table 10.9.8
AOC 698
Analytes Detected in Shallow Groundwater (μg/L)

Parameter	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Tap-water RBC/MCL	Shallow Groundwater
Volatile Organic Compounds							
2-Butanone (MEK)	698001	ND	ND	ND	2.000	190/NL	NA
Benzene	698001	5.0000	**16.000**	**7.0000**	**6.0000**	0.36/5	NA
Ethylbenzene	698001	12.0000	26.0000	9.0000	9.0000	130/700	NA
Toluene	698001	3.0000	3.0000	ND	ND	75/1,000	NA
Xylene (Total)	698001	15.0000	59.0000	ND	18.0000	1,200/10,000	NA
Semivolatile Organic Compounds							
2-Methylnaphthalene	698001	**26.0000**	**29.0000**	9.0000	11.0000	12/NL	NA
4-Methylphenol (p-Cresol)	698001	ND	ND	4.0000	2.0000	18/NL	NA
Carbazole	698001	ND	1.0000	ND	ND	3.3/NL	NA
Fluorene	698001	ND	3.0000	ND	ND	150/NL	NA
Naphthalene	698001	37.0000	27.0000	12.0000	20.0000	73/NL	NA
Pesticides							
alpha-BHC	698001	ND	ND	ND	**0.1500**	.01/NL	NA
delta-BHC	698001	**0.2100**	ND	ND	ND	.037/NL	NA
Endosulfan II	698001	0.2100	ND	ND	ND	.22/NL	NA

Table 10.9.8
AOC 698
Analytes Detected in Shallow Groundwater (μg/L)

Parameter	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Tap-water RBC/MCL	Shallow Groundwater
TPH							
Diesel	698001	6020.0000	6400.0000	NT	ND	NL/NL	NA
Gasoline	698001	450.0000	500.0000	NT	170.0000	NL/NL	NA
Inorganics							
Barium	698001	16.8000	13.5000	16.9000	14.5000	260/2,000	31.2
Calcium	698001	31500.0000	449000.0000	35300.0000	30800.0000	NL/NL	NA
Iron	698001	119.0000	ND	**13200.0000**	**10900.0000**	1,100/300	235
Lead	698001	ND	ND	3.300	ND	NL/15	1.94
Magnesium	698001	1670.0000	695.0000	2400.0000	1980.0000	NL/NL	NA
Manganese	698001	19.2000	ND	29.1000	20.6000	73/50	9.33
Potassium	698001	3130.0000	3000.0000	2490.0000	2530.0000	NL/NL	NA
Selenium	698001	2.4000	ND	ND	ND	18/50	NA
Sodium	698001	5540.0000	ND	4880.0000	ND	NL/NL	NA
Valadium	698001	1.0000	ND	1.80000	0.90000	26/NL	0.80
Zinc	698001	ND	ND	24.5000	ND	1,100/5,000	NA

Notes:
NA = Not applicable/not available/not analyzed
ND = Not detected/not determined
NL = Not listed
Only one sample from permanent well NBCR698001 was collected during each event.
Bold concentrations exceed the lower of the RBC/MCL, and when available, the shallow groundwater background concentration.

Volatile Organic Compounds in Groundwater

Five VOCs were detected in AOC 698 groundwater samples collected from the permanent well: MEK, benzene, toluene, ethylbenzene, and xylene. Of these, only benzene exceeded its tap-water RBC (0.36 μg/L). The RBC exceedance occurred in all four sampling rounds, with concentrations ranging from 5.0 to 16 μg/L. Benzene also exceeded its 5.0 μg/L MCL in rounds two through four. No other VOC exceeded their RBC or MCL.

Toluene and trichloroethene (TCE) were the only VOCs detected in the groundwater screening samples collected at AOC 698. Toluene did not exceed its RBC or MCL; TCE exceeded its RBC, but not its MCL. During the DPT sampling activities at AOC 698, DPT samples were also collected in the area of SWMU 166's TCE plume to further characterize the extent of contamination in that area. Samples from NBCK698S01, S02, and S03 were collected before samples from the TCE plume were collected. The sample from NBCK698S06 was collected immediately after all the solvent plume samples were collected. The TCE detection of 4 ppb at location NBCK698S06 is thought to be due to cross contamination from DPT locations near the solvent plume because of the low level of detection and the absence of TCE in any other AOC 698 sample.

Semivolatile Organic Compounds in Groundwater

Five SVOCs were detected in the groundwater samples from the permanent monitoring well at AOC 698: 2-methylnaphthalene, 4-methylphenol, carbazole, fluorene, and naphthalene. The SVOCs 2-methylnaphthalene and naphthalene were detected during all four sampling rounds. Carbazole and fluorene were detected only in the second-round sample. 4-methylphenol was detected in the third and fourth round sample. Only 2-methylnaphthalene exceeded an applicable RBC with detected concentrations ranging from 9.0 to 29.0 μg/L. These exceedances occurred in round one and two samples. All other SVOC concentrations were below the respective RBCs. No MCLs are listed for these SVOCs.

Pesticides/PCBs in Groundwater

Three pesticides were detected in the groundwater sample from the permanent monitoring well at AOC 698: alpha-BHC, delta-BHC and Endosulfan II. Each pesticide was detected during only one sampling round; delta-BHC and Endosulfan II occurred during round one and alpha-BHC during round four. Only the alpha-BHC and delta-BHC detections exceeded their respective tap-water RBCs. The alpha- and delta-BHC exceedances concentrations were 0.15 and 0.21 μg/L, respectively. No MCLs are listed for these three pesticide compounds.

Other Organic Compounds in Groundwater

TPH (DRO and GRO) was detected in the groundwater monitoring well during sampling rounds one and two. GRO-TPH was also detected during round four. The highest detected concentration of DRO and GRO was 6,400 μg/L and 500 μg/L, respectively. No TPH was detected in the groundwater screening samples.

Inorganics in Groundwater

Eleven metals were detected in groundwater at AOC 698. Only iron exceeded both its applicable RBC and background with detected concentrations ranging from 119 to 13,200 μg/L. Iron exceedances occurred during quarters three and four.

10.9.5 Fate and Transport Assessment for AOC 698

Environmental media sampled as part of the AOC 698 RFI are surface soil, subsurface soil, and shallow groundwater. Potential constituent migration pathways investigated for AOC 698 are soil-to-groundwater, risk-based groundwater transport, and emission of volatiles from surface soil-to-air.

10.9.5.1 AOC 698 — Soil-to-Groundwater Cross-media Transport

Tables 10.9.9 and 10.9.10 compare maximum detected organic and inorganic concentrations in surface soil and subsurface soil samples to risk-based soil screening levels considered protective of groundwater. To provide a conservative screen, generic soil screening levels are used; leachate entering the aquifer is assumed to be diluted by a ratio of 10:1, with no attenuation of constituents in soil (DAF=10).

Table 10.9.9
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, and Soil to Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: AOC 698
Charleston, South Carolina

Parameter	Maximum Concentration Surface Soil	Subsurfac Soil	Shallow GW	Screening Concentration * Soil to GW SSL	Tap Water RBC	Soil to Air SSL	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Volatil-ization Potential
Volatile Organic Compounds											
Benzene c	ND	ND	16	15	0.36	800	UG/KG	UG/L	NO	YES	NO
2-Butanone (MEK)	ND	ND	2	3900 a	1900	10000	UG/KG	UG/L	NO	NO	NO
Ethylbenzene	ND	ND	26	6500	1300	400000	UG/KG	UG/L	NO	NO	NO
Toluene	ND	ND	3	6000	750	650000	UG/KG	UG/L	NO	NO	NO
Xylene (total)	ND	ND	59	70000 a	12000	410000	UG/KG	UG/L	NO	NO	NO
Semivolatile Organic Compounds											
Anthracene	41	ND	ND	6000000	11000	NA	UG/KG	UG/L	NO	NO	NO
Benzo(g,h,i)perylene	1600	ND	ND	5.7E+07 a	730	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)pyrene equivalents (BEQs) c	2090	ND	ND	NA	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)anthracene c	550	ND	ND	800	0.092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(a)pyrene c	1300	ND	ND	4000	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(b)fluoranthene c	1500	ND	ND	2300 a	0.092	NA	UG/KG	UG/L	NO	NO	NO
Benzo(k)fluoranthene c	1700	ND	ND	25000	0.92	NA	UG/KG	UG/L	NO	NO	NO
Chrysene c	600	ND	ND	80000	9.2	NA	UG/KG	UG/L	NO	NO	NO
Dibenzo(a,h)anthracene c	410	ND	ND	800	0.0092	NA	UG/KG	UG/L	NO	NO	NO
Indeno(1,2,3-cd)pyrene c	1600	ND	ND	7000	0.092	NA	UG/KG	UG/L	NO	NO	NO
Butylbenzylphthalate c	150	ND	ND	930000	7300	930000	UG/KG	UG/L	NO	NO	NO
Carbazole c	ND	ND	1	300	3.3	NA	UG/KG	UG/L	NO	NO	NO
Dibenzofuran	100	ND	ND	6800 a	24	120000	UG/KG	UG/L	NO	NO	NO
bis(2-Ethylhexyl)phthalate (BEHP) c	120	ND	ND	1800000	4.8	3.1E+07	UG/KG	UG/L	NO	NO	NO
Fluoranthene	320	ND	ND	2100000	1500	NA	UG/KG	UG/L	NO	NO	NO
Fluorene	ND	ND	3	280000	1500	NA	UG/KG	UG/L	NO	NO	NO
2-Methylnaphthalene	300	ND	29	18000 a	120	NA	UG/KG	UG/L	NO	NO	NO
4-Methylphenol (p-cresol)	ND	ND	4	670 a	180	NA	UG/KG	UG/L	NO	NO	NO
Naphthalene	160	ND	37	31000 a	730	NA	UG/KG	UG/L	NO	NO	NO
Phenanthrene	360	ND	ND	660000 a	1100	NA	UG/KG	UG/L	NO	NO	NO
Phenol	2100	ND	ND	50000	22000	NA	UG/KG	UG/L	NO	NO	NO
Pyrene	560	ND	ND	2100000	1100	NA	UG/KG	UG/L	NO	NO	NO
Pesticides/PCB Compounds											
alpha-BHC c	ND	ND	0.15	0.5	0.011	800	UG/KG	UG/L	NO	YES	NO
delta-BHC c	ND	ND	0.21	1.8 a	0.037	NA	UG/KG	UG/L	NO	YES	NO
alpha-Chlordane c	55.2	ND	ND	5000 b	0.19	20000	UG/KG	UG/L	NO	NO	NO
gamma-Chlordane c	214	ND	ND	5000 b	0.19	20000	UG/KG	UG/L	NO	NO	NO
4,4'-DDD c	54	ND	ND	8000	0.28	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDE c	990	ND	ND	27000	0.2	NA	UG/KG	UG/L	NO	NO	NO
4,4'-DDT c	370	ND	ND	16000	0.2	1.0E+09	UG/KG	UG/L	NO	NO	NO
Dieldrin c	6.59	ND	ND	2	0.0042	1000	UG/KG	UG/L	YES	NO	NO
Endosulfan II	ND	ND	0.21	9000 b	220	NA	UG/KG	UG/L	NO	NO	NO
Endosulfan sulfate	5.94	ND	ND	4600 a	220	NA	UG/KG	UG/L	NO	NO	NO
Endrin	27	ND	ND	500	11	NA	UG/KG	UG/L	NO	NO	NO
Endrin aldehyde	15	ND	ND	340 a	11	NA	UG/KG	UG/L	NO	NO	NO
Endrin ketone	9.79	ND	ND	340 a	11	NA	UG/KG	UG/L	NO	NO	NO
Heptachlor c	9.5	ND	ND	11000	0.0023	100	UG/KG	UG/L	NO	NO	NO
Heptachlor epoxide c	140	ND	ND	330	0.0012	5000	UG/KG	UG/L	NO	NO	NO
Dioxin Compounds											
2378-TCDD Equivalents (TEQs) c	11.9	NA	NA	1600 a	0.45	NA	NG/KG	PG/L	NO	NO	NO
2378-TCDD c	2.12	NA	NA	1600 a	0.45	NA	NG/KG	PG/L	NO	NO	NO
123478-HxCDD c	2.05	NA	NA	4100 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
123678-HxCDD c	6.91	NA	NA	4100 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
123789-HxCDD c	5.2	NA	NA	4100 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDD c	306	NA	NA	110000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDD c	2240	NA	NA	1100000 a	450	NA	NG/KG	PG/L	NO	NO	NO
12378-PeCDF c	0.926	NA	NA	770 a	8.9	NA	NG/KG	PG/L	NO	NO	NO
123478-HxCDF c	8.81	NA	NA	220000 a	4.5	NA	NG/KG	PG/L	NO	NO	NO

Table 10.9.9
Organic Compounds Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, and Soil to Air SSLs
Charleston Naval Complex, Zone K, Naval Annex: AOC 698
Charleston, South Carolina

	Maximum Concentration			Screening Concentration *							
Parameter	Surface Soil	Subsurfac Soil	Shallow GW	Soil to GW SSL	Tap Water RBC	Soil to Air SSL	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Volatil-ization Potential
123678-HxCDF c	4.46	NA	NA	220000 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
234678-HxCDF c	7.2	NA	NA	220000 a	4.5	NA	NG/KG	PG/L	NO	NO	NO
1234678-HpCDF c	84	NA	NA	54000 a	45	NA	NG/KG	PG/L	NO	NO	NO
1234789-HpCDF c	1.92	NA	NA	54000 a	45	NA	NG/KG	PG/L	NO	NO	NO
OCDF c	129	NA	NA	540000 a	450	NA	NG/KG	PG/L	NO	NO	NO
TPH - Diesel Range Organics											
Diesel	149000	NA	6400	NA	NA	NA	UG/KG	UG/L	NO	NO	NO
TPH - Gasoline Range Organics											
Gasoline	ND	NA	500	NA	NA	NA	UG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.6.
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.9.2 and 10.9.6.

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Based on surrogate compound (See Table 5.6)
c - Carcinogen
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration

SSL - Soil screening level
MG/KG - Milligrams per kilogram
NG/KG - Nanograms per kilogram
UG/KG - Micrograms per kilogram
PG/L - Picograms per liter
UG/L - Micrograms per liter

Table 10.9.10
Inorganic Chemicals Detected in Surface Soil, Subsurface Soil, and Shallow Groundwater
Comparison to Soil to Groundwater SSLs, Tap Water RBCs, Soil to Air SSLs, and Background Reference Values
Charleston Naval Complex, Zone K, Naval Annex: AOC 698
Charleston, South Carolina

Parameter	Maximum Concentration			Screening Concentration									
	Surface Soil	Subsurface Soil	Shallow GW	Soil to GW SSL	Soil Background Reference	Soil to Air SSL	Tap Water RBC	GW Background Reference	Soil Units	Water Units	Leaching Potential	Ground-Water Migration Concern	Fugitive Particulate Inhalation Concern
Inorganics													
Aluminum	5940	6910	ND	560000 a	11200	NA	37000	471	MG/KG	UG/L	NO	NO	NO
Antimony	0.53	ND	ND	2.7	0.45	NA	15	NA	MG/KG	UG/L	NO	NO	NO
Arsenic c	10.5	3.4	ND	15	3	750	0.045	NA	MG/KG	UG/L	NO	NO	NO
Barium	105	3.6	16.9	820	25.6	690000	2600	31.2	MG/KG	UG/L	NO	NO	NO
Beryllium	0.65	ND	ND	32	0.17	1300	73	NA	MG/KG	UG/L	NO	NO	NO
Cadmium	4	ND	ND	3.8 a	0.13	1800	18	NA	MG/KG	UG/L	YES	NO	NO
Chromium (total)	10.7	6.3	ND	19 b	8.76	270	110	NA	MG/KG	UG/L	NO	NO	NO
Cobalt	2	0.23	ND	990 a	0.62	NA	2200	NA	MG/KG	UG/L	NO	NO	NO
Copper	30.7	0.45	ND	5600 a	3.86	NA	1500	2.8	MG/KG	UG/L	NO	NO	NO
Lead	119	3.2	3.3	400 d	39.6	400	15	1.9	MG/KG	UG/L	NO	NO	NO
Manganese	70.4	2.8	29.1	480 a	26.4	NA	730	9.3	MG/KG	UG/L	NO	NO	NO
Mercury	0.16	ND	ND	1	NA	10	11	NA	MG/KG	UG/L	NO	NO	NO
Nickel	6.7	2.4	ND	65	2.64	13000	730	NA	MG/KG	UG/L	NO	NO	NO
Selenium	ND	ND	2.4	2.6	0.84	NA	180	NA	MG/KG	UG/L	NO	NO	NO
Tin	9.8	10.4	ND	5500 a	19.4	NA	22000	102	MG/KG	UG/L	NO	NO	NO
Vanadium	9.3	16.7	1.8	3000	15.8	NA	260	0.8	MG/KG	UG/L	NO	NO	NO
Zinc	296	ND	24.5	6200	14.8	NA	11000	NA	MG/KG	UG/L	NO	NO	NO

Notes:
Sources of screening concentrations appear in Table 5.7.
Explanations of fate and transport screening procedures appear in Section 6.2.
Frequency and range of detections, average detected concentrations, and number of screening concentration exceedances appear in Tables 10.9.3 and 10.9.7.

Background reference values for soil are shown for comparison purposes only.
Maximum groundwater concentrations are screened against the greater of tap water RBCs or corresponding background reference values to determine groundwater migration

a - Calculated soil to groundwater SSL value (See Table 6.4)
b - Assumes hexachrome
c - Carcinogen
d - USEPA de facto residential soil level
GW - Groundwater
NA - Not available/Not applicable
ND - Not detected
RBC - Risk-based concentration
SSL - Soil screening level
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

One organic compound in soil exceeded its groundwater protection standard. Dieldrin was detected at a concentration of 6.59 μg/kg in a duplicate surface soil sample collected from location 698SB002, which exceeds its groundwater protection SSL of 2 μg/kg. However, it was not detected in groundwater and therefore the pathway is not considered.

Cadmium was detected at a concentration equal to its SSL at one surface location. However, it was not detected in subsurface soil or groundwater, thus, the pathway is considered invalid.

10.9.5.2 AOC 698 — Risk-Based Groundwater Transport

Tables 10.9.9 and 10.9.10 also compare maximum detected organic and inorganic constituent concentrations in shallow groundwater samples to risk-based concentrations for drinking water. For inorganics, maximum concentrations in groundwater are also compared to risk-based drinking water concentrations. To provide a conservative screen, no attenuation or dilution of constituents in groundwater is assumed before comparison to the relevant standards. It should be noted that this pathway is considered invalid simply due to non-use of the resource.

Four organic compounds in AOC 698 groundwater exceeded risk-based drinking water concentrations: benzene, 2-methylnaphthalene, alpha-BHC and delta-BHC. Benzene was detected in samples from all four rounds from the permanent monitoring well at concentrations exceeding its tap-water RBC. However, it was not detected in any of the groundwater screening samples collected around the AOC 698 monitoring well location. The absence of benzene in the screening samples suggests that benzene has not migrated significantly from the area of the AST. 2-methlynaphthalene was detected in a single sample during the first two quarters. It was below the RBC in the third- and fourth-quarters and, therefore not suspected to be significant. Alpha-BHC exceeded its RBC at one sampling location during the fourth sampling quarter. However, delta-BHC was not detected in the second, third, or fourth sampling rounds, indicating that its presence in the first sampling round may have been related to well installation.

No inorganics in AOC 698 groundwater exceeded risk-based drinking water concentrations.

10.9.5.3 AOC 698 — Soil-to-Air Cross-Media Transport

No VOCs were detected in surface soil samples collected at AOC 698. As a result, the soil-to-air migration pathway is not considered to be valid at AOC 698.

10.9.5.4 AOC 698 — Fate and Transport Summary

Dieldrin and cadmium were present in soil above their SSLs. However, neither was detected in site groundwater, thus the pathway is considered invalid with respect to them. Four organic groundwater constituents (benzene, 2-methylnaphthalene, alpha-BHC, and delta-BHC) at AOC 698 exceeded their risk-based drinking water standards. However, they are not considered significant fate and transport concerns and, therefore, not recommended for further fate and transport assessment due to the limited spatial distribution of benzene and delta-BHC and the fact that 2-methylnapthalene and alpha-BHC concentrations have open below RBC during the last two sampling rounds.

No other fate and transport concerns were identified at AOC 698.

10.9.6 Human Health Risk Assessment for AOC 698

10.9.6.1 Site Background and Investigative Approach

AOC 698 is the former boiler house, Building 2508, at the Naval Annex. Materials of concern due to past site operations are lead and petroleum hydrocarbons.

During the CSI, 20 upper-interval and 16 lower-interval soil samples were collected to identify potential impacts resulting from the activities listed above. Surface soil samples from all boring locations were used to quantitatively assess surface soil exposure pathways. Subsurface soil samples were addressed in the previous section. One monitoring well was installed for AOC 698 and data from all sampling events were used to quantitatively assess the groundwater pathways. Sections 10.9.1 and 10.9.3 summarize the sampling effort for AOC 698 soil and groundwater.

10.9.6.2 COPC Identification

Soil

Based on the screening comparisons described in Section 7 of this CSI and presented in Table 10.9.11, arsenic, BEQs, cadmium, and heptachlor epoxide are COPCs in surface soil.

Groundwater

As shown in Table 10.9.12, benzene, 2-methylnaphthalene, alpha-BHC, and delta-BHC are COPCs for shallow groundwater at AOC 698.

10.9.6.3 Exposure Assessment

Exposure Setting

AOC 698 is the area surrounding Building 2508 and the associated AST, which in a concrete containment bunker 35 feet from the building.

Potentially Exposed Populations

Potentially exposed populations are current and future site workers. Additional potentially exposed populations are hypothetical future site residents. Future site resident and worker exposure scenarios were addressed quantitatively in this risk assessment. Current exposure to workers is discussed qualitatively in relation to the future workers and future residents. The hypothetical future site worker scenario assumes continuous exposure to surface soil conditions. Current site workers' exposure would be less than that assumed for the hypothetical future site worker scenario because of their limited soil contact. Therefore, future worker assessment is considered to be conservatively representative of current site users. The future site resident scenario was built on the premise that existing fixtures would be removed and replaced with dwellings.

Table 10.9.11
Chemicals Present in Site Samples
AOC 698 - Surface Soil
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
Carcinogenic PAHs													
Benzo(a)pyrene equivalents	*	2	12	28.06	2092.6	1060.3	670.2	4391	87	NA	UG/KG	1	
Benzo(a)pyrene	*	1	12	1300	1300	1300	290	1900	87	NA	UG/KG	1	
Benzo(a)anthracene		1	12	550	550	550	290	1900	870	NA	UG/KG		
Benzo(b)fluoranthene	*	2	12	110	1500	805	290	1900	870	NA	UG/KG	1	
Benzo(k)fluoranthene		2	12	93	1700	897	290	1900	8700	NA	UG/KG		
Chrysene		2	12	130	600	365	290	1900	87000	NA	UG/KG		
Dibenz(a,h)anthracene	*	1	12	410	410	410	290	1900	87	NA	UG/KG	1	
Indeno(1,2,3-cd)pyrene	*	2	12	160	1600	880	290	1900	870	NA	UG/KG	1	
TPH - Diesel Range Organics													
Diesel		1	1	149	149	149	NA	NA	NA	NA	MG/KG		
TCDD Equivalents													
1234678-HpCDD		1	1	306	306	306	NA	NA	NA	NA	NG/KG		
1234678-HpCDF		1	1	84	84	84	NA	NA	NA	NA	NG/KG		
1234789-HpCDF		1	1	1.92	1.92	1.92	NA	NA	NA	NA	NG/KG		
123478-HxCDD		1	1	2.05	2.05	2.05	NA	NA	NA	NA	NG/KG		
123478-HxCDF		1	1	8.81	8.81	8.81	NA	NA	NA	NA	NG/KG		
123678-HxCDD		1	1	6.91	6.91	6.91	NA	NA	NA	NA	NG/KG		
123678-HxCDF		1	1	4.46	4.46	4.46	NA	NA	NA	NA	NG/KG		
123789-HxCDD		1	1	5.2	5.2	5.2	NA	NA	NA	NA	NG/KG		
12378-PeCDF		1	1	0.926	0.926	0.926	NA	NA	NA	NA	NG/KG		
234678-HxCDF		1	1	7.2	7.2	7.2	NA	NA	NA	NA	NG/KG		
2378-TCDD		1	1	2.12	2.12	2.12	NA	NA	NA	NA	NG/KG		
Dioxin Equiv.		1	1	11.92	11.92	11.92	NA	NA	1000[b]	NA	NG/KG		
OCDD		1	1	2240	2240	2240	NA	NA	NA	NA	NG/KG		
OCDF		1	1	129	129	129	NA	NA	NA	NA	NG/KG		
Inorganics													
Aluminum (Al)		8	8	4590	5940	5120	NA	NA	7800	11200	MG/KG		
Antimony (Sb)		3	8	0.44	0.53	0.49	0.38	0.4	3.1	0.45	MG/KG		2
Arsenic (As)	*	8	8	0.98	10.5	4.47	NA	NA	0.43	3	MG/KG	8	5
Barium (Ba)		8	8	9.9	105	27.74	NA	NA	550	25.6	MG/KG		2
Beryllium (Be)		4	8	0.06	0.65	0.22	0.02	0.02	16	0.17	MG/KG		1
Cadmium (Cd)	*	5	8	0.1	4	1.10	0.04	0.04	3.9	0.13	MG/KG	1	4
Calcium (Ca)		8	8	96.5	4150	1450	NA	NA	NA	NA	MG/KG		
Chromium (Cr)		8	8	2.5	10.7	4.87	NA	NA	23	8.4	MG/KG		1
Cobalt (Co)		4	8	0.2	2	0.72	0.13	0.13	470	0.34	MG/KG		2
Copper (Cu)		8	8	0.71	30.7	9.02	NA	NA	310	3.86	MG/KG		4
Iron (Fe)		8	8	1240	7160	2831	NA	NA	2300	7060	MG/KG	5	1
Lead (Pb)		8	8	5.2	119	54.06	NA	NA	400	39.6	MG/KG		4
Magnesium (Mg)		8	8	80	505	175	NA	NA	NA	NA	MG/KG		
Manganese (Mn)	a	8	8	5.7	70.4	18.92	NA	NA	1100	26.4	MG/KG		1
Mercury (Hg)		4	8	0.06	0.16	0.11	0.05	0.06	2.3	NA	MG/KG		
Nickel (Ni)		8	8	0.2	6.7	1.79	NA	NA	160	1.7	MG/KG		3
Potassium (K)		8	8	31	192	79.17	NA	NA	NA	NA	MG/KG		
Sodium (Na)		8	8	6.4	131	30.96	NA	NA	NA	NA	MG/KG		
Tin (Sn)		1	8	9.8	9.8	9.80	10.5	12.7	4700	19.4	MG/KG		
Vanadium (V)		8	8	4.5	9.3	7.02	NA	NA	55	15.8	MG/KG		
Zinc (Zn)		7	8	12.5	296	129	6.9	6.9	2300	14.8	MG/KG		6
Pesticides													
4,4'-DDD		2	9	4.38	54	29.2	2.6	2.8	2700	NA	UG/KG		
4,4'-DDE		8	9	3.3	990	139	3.35	3.35	1900	NA	UG/KG		
4,4'-DDT		9	9	5.4	370	65.4	NA	NA	1900	NA	UG/KG		
alpha-Chlordane		4	9	2.6	55.2	28.6	1.4	1.9	1800	NA	UG/KG		
Dieldrin		1	9	6.59	6.59	6.59	2.4	2.8	40	NA	UG/KG		
Endosulfan sulfate		1	9	5.94	5.94	5.94	2.4	14	47000	NA	UG/KG		
Endrin		1	9	27	27	27	2.4	3.35	2300	NA	UG/KG		
Endrin aldehyde		1	9	15	15	15	2.4	3.35	2300	NA	UG/KG		
Endrin ketone		2	9	5.2	9.79	7.5	2.4	14	2300	NA	UG/KG		
gamma-Chlordane		6	9	1.7	214	50.9	1.2	1.4	1800	NA	UG/KG		
Heptachlor		1	9	9.5	9.5	9.5	0.46	1.72	140	NA	UG/KG		
Heptachlor epoxide	*	4	9	2.2	140	69.4	1.2	1.4	70	NA	UG/KG	1	
Semivolatile Organics													
Anthracene		1	12	41	41	41	290	1900	2300000	NA	UG/KG		
Benzo(g,h,i)perylene		1	12	1600	1600	1600	290	1900	160000	NA	UG/KG		
Butylbenzylphthalate		1	12	150	150	150	290	1900	1600000	NA	UG/KG		
Dibenzofuran		1	12	100	100	100	290	1900	31000	NA	UG/KG		
bis(2-Ethylhexyl)phthalate		2	12	98	120	109	290	1900	46000	NA	UG/KG		
Fluoranthene		2	12	210	320	265	290	1900	310000	NA	UG/KG		
Naphthalene		2	12	55	160	108	290	1900	160000	NA	UG/KG		
Phenanthrene		2	12	90	360	225	290	1900	160000	NA	UG/KG		
Phenol		2	12	100	2100	1100	330	440	4700000	NA	UG/KG		
Pyrene		2	12	200	560	380	290	1900	230000	NA	UG/KG		

Notes:
* - Indicates chemical was identified as a COPC
a - The food RBC was used as a screening value for concentration of manganese reported in soil
b - Reported soil concentrations of dioxin (as TEQs) were compard to the project screening level.
SQL - Sample quantitation limit
RBC - Risk-based concentration
UG/KG - micrograms per kilogram
NG/KG - nanograms per kilogram
MG/KG - milligrams per kilogram
NA - Not applicable or not available

Table 10.9.12
Chemicals Present in Site Samples
AOC 698 - Groundwater
Charleston Naval Complex, Zone K
Charleston, South Carolina

Parameter		Frequency of Detection		Range of Detection		Average Detected Concentration	Range of SQL		Screening Concentration Residential RBC	Reference	Units	Number Exceeding RBC	Ref
TPH - Diesel Range Organics													
Diesel		2	3	6.02	6.4	6.21	4.3	4.3	NA	NA	MG/L		
TPH - Gasoline Range Organics													
Gasoline		3	3	170	500	373.33	NA	NA	NA	NA	UG/L		
Inorganics													
Barium (Ba)		4	4	13.5	16.9	15.43	NA	NA	260	31.2	UG/L		
Calcium (Ca)		4	4	30800	44900	35625	NA	NA	NA	NA	UG/L		
Iron (Fe)		3	4	119	13200	8073	NA	NA	1100	220	UG/L		
Lead (Pb)		1	4	3.3	3.3	3.3	0.89	1.9	15	1.9	UG/L		1
Magnesium (Mg)		4	4	695	2400	1686.25	NA	NA	NA	NA	UG/L		
Manganese (Mn)	a	3	4	19.2	29.1	22.97	4.6	4.6	73	9.3	UG/L		3
Potassium (K)		4	4	2490	3130	2787.5	NA	NA	NA	NA	UG/L		
Selenium (Se)		1	4	2.4	2.4	2.4	NA	NA	18	NA	UG/L		
Sodium (Na)		2	4	4880	5540	5210	2300	3030	NA	NA	UG/L		
Vanadium (V)		3	4	0.9	1.8	1.23	1.3	1.3	26	0.8	UG/L		3
Zinc (Zn)		1	4	24.5	24.5	24.5	5.5	48.4	1100	NA	UG/L		
Pesticides													
alpha-BHC	*	1	4	0.15	0.15	0.15	0.05	0.059	0.011	NA	UG/L	1	
delta-BHC	*	1	4	0.21	0.21	0.21	0.025	0.059	0.011	NA	UG/L	1	
Endosulfan II		1	4	0.21	0.21	0.21	0.05	0.118	22	NA	UG/L		
Semivolatile Organics													
Carbazole		1	4	1	1	1	10	11	3.3	NA	UG/L		
Fluorene		1	4	3	3	3	10	11	150	NA	UG/L		
4-Methylphenol		2	4	2	4	3	10	10	18	NA	UG/L		
2-Methylnaphthalene	*	4	4	9	29	18.75	NA	NA	12	NA	UG/L	2	
Naphthalene		4	4	12	37	37	NA	NA	73	NA	UG/L		
Volatile Organics													
Benzene	*	4	4	5	16	8.5	NA	NA	0.36	NA	UG/L	4	
2-Butanone		1	4	2	2	2	10	10	190	NA	UG/L		
Ethylbenzene		4	4	9	26	14	NA	NA	130	NA	UG/L		
Toluene		2	4	3	3	3	5	5	75	NA	UG/L		
Xylene (Total)		3	4	15	59	30.67	30	30	1200	NA	UG/L		

Notes:
* - Indicates chemical was identified as a COPC
a - The nonfood RBC was used as the screening value for concentrations of manganese reported in groundwater
SQL - Sample quantitation limit
RBC - Risk-based concentration
MG/L - milligrams per liter
UG/L - micrograms per liter
NA - Not applicable or not available

Exposure Pathways

Exposure pathways for the hypothetical future site residents and site workers are dermal contact and incidental ingestion of surface soils. The exposure pathways for current site workers are the same as those for the future site residents with respect to soil. Uniform exposure was assumed for all sample locations. The groundwater pathway for the hypothetical future site residents and site workers is incidental ingestion of groundwater and inhalation of VOCs volatilized following domestic or process uses of groundwater. Table 10.9.13 presents the justification for exposure pathways assessed in this HHRA.

Table 10.9.13
Exposure Pathways Summary — AOC 698
CNC — Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Users (Site Workers)	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 698.
	Shallow groundwater, inhalation of volatilized shallow groundwater contaminants	No	Shallow groundwater is not currently used as a source of potable or non-residential water at AOC 698.
	Soil, incidental ingestion	No (Qualified)	Future site use is considered conservatively representative of current site use.
	Soil, dermal contact	No (Qualified)	Future site use is considered conservatively representative of current site use.

Table 10.9.13
Exposure Pathways Summary — AOC 698
CNC — Zone K
Charleston, South Carolina

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Uses			
Future Site Residents (Child and Adult), Future Site Worker	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Shallow groundwater, ingestion of contaminants during potable or general use	Yes	Shallow groundwater is not likely to be used as a source of potable or non-residential water at AOC 698. This pathway was addressed as a conservative measure.
	Shallow groundwater, inhalation of volatilized contaminants during domestic use	Yes	Volatile COPCs were identified subsequent to risk-based screening comparisons.
	Soil, incidental ingestion	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Soil, dermal contact	Yes	COPCs were identified subsequent to risk-based and background screening comparisons.
	Wild game or domestic animals, ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina, city limits.
	Fruits and vegetables, Ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Exposure Point Concentrations

Since fewer than 10 surface soil samples were collected, maximum detected concentrations were used as exposure point concentrations, as discussed in Section 7 of this RFI. Since only one monitoring well was established for AOC 698, the COPC concentrations reported in the first-quarter sample were used as EPCs.

Quantification of Exposure

CDIs for ingestion and dermal contact with soils are shown in Tables 10.9.14 and 10.9.15, respectively. CDIs for the groundwater pathway are shown in Table 10.9.16.

Table 10.9.14
Chronic Daily Intakes
Incidental Ingestion of Surface Soil
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Fraction Ingested from Contaminated Source *	Exposure Point Concentration (mg/kg)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganics							
Arsenic (As)	1	10.5	1.4E-05	1.3E-04	1.6E-05	5.1E-06	1.8E-06
Cadmium (Cd)	1	4	5.5E-06	5.1E-05	6.3E-06	2.0E-06	7.0E-07
Carcinogenic PAHs							
Benzo(a)pyrene equivalents	1	2.03	2.8E-06	2.6E-05	3.2E-06	9.9E-07	3.5E-07
Pesticides							
Heptachlor epoxide	1	0.14	1.9E-07	1.8E-06	2.2E-07	6.8E-08	2.4E-08

NOTES:

LWA Lifetime-weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B.
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.

Table 10.9.15
Chronic Daily Intakes
Dermal Contact with Surface Soil
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	FI/FC *	Exposure Point Concentration (mg/kg)	Dermal Absorption Factor (unitless)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Current Worker adult H-CDI (mg/kg-day)	Current Worker adult C-CDI (mg/kg-day)
Inorganics								
Arsenic (As)	1	10.5	0.001	5.9E-07	1.9E-06	3.7E-07	4.2E-07	1.5E-07
Cadmium (Cd)	1	4	0.001	2.2E-07	7.4E-07	1.4E-07	1.6E-07	5.7E-08
Carcinogenic PAHs								
Benzo(a)pyrene Equivalents	1	2.03	0.01	1.1E-06	3.8E-06	7.1E-07	8.1E-07	2.9E-07
Pesticides								
Heptachlor epoxide	1	0.14	0.01	7.9E-08	2.6E-07	4.9E-08	5.6E-08	2.0E-08

NOTES:
CDI Chronic Daily Intake in mg/kg-day
H-CDI CDI for hazard quotient
C-CDI CDI for excess cancer risk
* Reflects the estimated fraction of the site impacted by the corresponding COPC.
\- The dermal absorption factor was applied to the exposure point concentration to reflect the ability for trans-dermal migration of inorganic and organic chemicals

Table 10.9.16
Chronic Daily Intakes
Ingestion of COPCs in Shallow Groundwater
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Exposure Point Concentration (mg/liter)	Future Resident adult H-CDI (mg/kg-day)	Future Resident child H-CDI (mg/kg-day)	Future Resident LWA C-CDI (mg/kg-day)	Future Worker adult H-CDI (mg/kg-day)	Future Worker adult C-CDI (mg/kg-day)
Pesticides						
delta-BHC	0.00021	5.75E-06	1.34E-05	3.16E-06	2.05E-06	1.01E-06
Volatile Organics						
Benzene	0.005	1.37E-04	3.20E-04	7.53E-05	4.89E-05	2.41E-05

NOTES:
LWA Lifetime-weighted average
CDI Chronic Daily Intake
H-CDI Non-carcinogenic hazard based Chronic Daily Intake
C-CDI Carcinogenic risk based Chronic Daily Intake

10.9.6.4 Toxicity Assessment

Toxicity assessment terms and methods are discussed in Section 7 of this report. Table 10.9.17 presents toxicological information specific to each COPC identified at AOC 698. This information was used in the quantification of risk/hazard associated with soil contaminants. Each COPC's toxicology is briefly profiled in the following paragraphs.

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects (Klaassen, et al., 1986). USEPA set 0.0003 mg/kg/day as the RfD for arsenic. As listed in IRIS, the critical effect of this chemical is hyperpigmentation, keratosis, and possible vascular complications. Arsenic's effects on the nervous and cardiovascular systems are primarily associated with acute exposure to higher levels. Exposure to arsenic-containing materials has been shown to cause cancer in humans. Inhalation of these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg/day)^{-1}$ SF. As listed in IRIS, the basis for the classification is sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic.

Benzene is a VOC associated with leukemia. This chemical has been used as a solvent in coal tar naphtha, rubber, and plastic cement. USEPA lists benzene as a group A carcinogen. In large doses, benzene depresses the central nervous system, and chronic exposure depresses bone marrow production. The oral SF for benzene was set by USEPA as 2.9E-2 $(mg/kg\text{-}day)^{-1}$; an oral RfD has

Table 10.9.17
Toxicological Reference Information
for Chemicals of Potential Concern
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

	Non-Carcinogenic Toxicity Data											*Carcinogenic Toxicity Data*					
Chemical	Oral Reference Dose (mg/kg-day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg-day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation		Oral Slope Factor (kg-day/mg)		Inhalation Slope Factor (kg-day/mg)		Weight of Evidence	Tumor Type
Arsenic	0.0003	a	M	hyperpigmentation	3	NA		NA	NA	NA		1.5	a	15.1	a	A	various
Beryllium	0.005	a	L	microscopic organ changes	100	NA		NA	NA	NA		4.3	a	8.4	a	B2	osteosarcoma
Benzene	NA		NA	NA	NA	0.00171	b	NA	NA	NA		0.029	a	0.029	a	A	leukemia
Cadmium (food)	0.001	a	H	proteinuria	10	NA		NA	NA	NA		NA		6.3	a	B1	lung
delta-BHC	NA		NA	NA	NA	NA		NA	NA	1.8	a	NA		1.79	a	NA	NA
Heptachlor epoxide	0.000013	a	L	liver weight increase	1000	NA		NA	NA	NA		9.1	a	NA		B2	liver carcinoma

Notes:

a = Integrated Risk Information System (IRIS)
b = Withdrawn from IRIS/HEAST
A = Known human carcinogen
B1 = Probable human carcingogen based on human exposure data.
B2 = Possible human carcinogen based on laboratory animal study data.
NA = Not applicable or not available
H = High confidence
L = Low confidence
M = Medium confidence

not been set. Occupational inhalation exposure to benzene is acceptable by OSHA at concentrations of 3.25 milligrams per cubic meter $(mg/m)^3$ or 1 ppm in air (Dreisbach et al; 1987; NIOSH, 1990).

Benzo(a)pyrene equivalents include the following polynuclear aromatic hydrocarbons:

	TEF
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Dibenz(a,h)anthracene	1.0
Benzo(k)fluoranthene	0.01
Benzo(a)pyrene	1.0
Indeno(1,2,3-cd)pyrene	0.1
Chrysene	0.001

Some PAHs are toxic to the liver, kidney, and blood. However, the toxic effects of the PAHs above have not been well established and they have no RfDs due to a lack of data. All PAHs listed above are classified by USEPA as B2 carcinogens, and their carcinogenicity is addressed relative to that of benzo(a)pyrene, having an oral SF of 7.3 $(mg/kg\text{-}day)^{-1}$. Toxicity equivalency factors (TEFs), also set by USEPA, are multipliers that are applied to the detected concentrations, which are subsequently used to calculate excess cancer risk. Most carcinogenic PAHs have been classified as such due to animal studies using large doses of purified PAHs. There is some doubt as to the validity of these listings, and the SFs listed in USEPA's RBC table are provisional. However, these PAHs are carcinogens when the exposure involves a mixture of other carcinogenic substances (e.g., coal tar, soot, cigarette smoke). As listed in IRIS, the basis for the benzo(a)pyrene B2 classification is animal studies. Human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic by numerous routes.

Cadmium can upset the stomach, leading to vomiting and diarrhea in acute exposure; acute inhalation of cadmium-containing dust can irritate the lungs. Chronic exposure to cadmium, either via inhalation or ingestion, has been shown to cause kidney damage (including kidney stones), emphysema, and high blood pressure. Other tissues reported to be injured by cadmium exposure in animals and humans include the lungs, testes, liver, immune system, blood, and the nervous system (Klaassen et al., 1986). An oral RfD of 0.001 mg/kg/day has been determined by USEPA, based on human studies (food) involving chronic exposure in which significant increased protein was present in the urine. A separate oral RfD for water has been determined by USEPA to be 0.0005 mg/kg/day. For inhalation exposure, cadmium has been classified by USEPA as a group B1, or probable human carcinogen, based on limited evidence from epidemiological studies in which an excess risk of lung cancer was observed in cadmium smelter workers. As listed in IRIS, the classification is based on limited evidence from occupational epidemiologic studies consistent across investigations and study populations. There is sufficient evidence of carcinogenicity in rats and mice by inhalation and intramuscular and subcutaneous injection. Seven rat and mice studies where cadmium salts (acetate, sulfate, chloride) were administered orally have shown no evidence of carcinogenic response. However, there is sufficient evidence of increased risk of lung cancer in rats and mice exposed to cadmium via inhalation. Seven studies in which cadmium was administered orally to rats and mice have shown no evidence of carcinogenic response following exposure via this route.

Hexachlorocyclohexane or ***(HCH)*** is made by chlorinating benzene, and was previously, erroneously called ***benzenehexachloride (BHC)***. HCH is a synthetic chemical in eight isomers. One of the isomers, gamma (γ)-HCH (commonly called ***lindane***) was once used as an insecticide on fruit, vegetable, and forest crops. It is still used today in the United States and in other countries as a human medicine to treat head and body lice and scabies. Although HCH is no longer used as an insecticide in the United States, α, β, γ, and δ- HCH have been identified in the soil and surface water at hazardous waste sites.

Exposure to excessive amounts of HCH, primarily γ-HCH, by inhalation or ingestion, has been reported to result in death in humans. The cause of acute lethality of HCH in animals may be its effects on the central nervous system since convulsions and coma were often observed in victims prior to their deaths. The doses associated with death and increased mortality in animals are much higher than would be present in the environment or in water or soil surrounding waste sites, so it is not likely that humans would die following either brief or prolonged exposure to HCH in food, water, or soil.

Blood disorders, including anemia, leukopenia, leukocytosis, granulocytopenia, granulocytosis, eosinophilia, monocytosis, pancytopenia, and thrombocytopenia have been observed in individuals exposed to γ-HCH where HCH vaporizers were operated (Brassow et al., 1981). In animals, hematological effects were observed in rats fed δ- HCH in the diet for 13 weeks (Van Velsen et al., 1986).

Hepatic effects, such as increased liver enzymes, have been reported in individuals exposed to technical-grade HCH, principally by inhalation in a pesticide-formulating plant (Kashyap, 1986); similar effects were not reported in individuals who ingested HCH or applied γ-HCH to their skin.

In humans, neurological effects, including parathesis of the face and extremities, headaches, vertigo, abnormal EEG patterns and often seizures and convulsions have been reported in individuals occupationally exposed to γ-HCH or in individuals exposed to large amounts of γ-HCH by ingestion or dermal application (Czegledi-Janko and Avar, 1970; Davies et al., 1983; Harris et al., 1969; Heiberg and Wright, 1955; Kashyap, 1986; Lee and Groth, 1977; Matsuoka, 1981, Munk and Nantel, 1977; Nantel, 1977; Powell, 1980; Starr and Clifford, 1972; Telch and Jarvis, 1982). Acute- and intermediate-duration exposure of animals to high oral or dermal doses of γ- or β- HCH affects the central nervous system, as evidenced by behavior disorders, decreased nerve velocity, convulsions and seizures, and coma (Albertson et al., 1985; Desi, 1974; Hanig et al., 1976; Muller et al., 1981; Tilson et al., 1987; Tusell et al., 1987; Van Velsen et al., 1986). No histological examinations were conducted on the brain or nervous system of animals exposed by any route for any duration. There is no evidence available regarding the presence or absence of carcinogenic effects in humans following exposure by any route. Weight of evidence, cancer slope factors and reference doses for each of the HCH isomers are shown in the table below:

HCH isomer	Weight of Evidence Class	Oral RfD	Oral SF	Inhalation SF
α- HCH	B2[a]	NA	6.3E+00[a]	6.3E+00[a]
β- HCH	C[a]	NA	1.8E+00[a]	1.8E+00[a]
γ- HCH	B2-C[b]	3.0E-04[a]	1.3E+00[b]	NA
δ- HCH	NA	NA	NA	NA
-technical	NA	NA	1.8E+00[a]	1.8E+00[a]

Notes:
a - Taken from IRIS, 1996
b - Taken from HEAST, 1996
NA - Not applicable/not available/not analyzed
RfD - Reference dose
SF - Slope factor

Heptachlor epoxide is the more toxic form of the insecticide heptachlor, which has been used to control flies, mosquitoes, and field insects in the past. Benign and malignant liver tumors were induced in three strains of mice of both sexes. Heptachlor epoxide has been linked to liver carcinoma (Dreisbach, et al., 1987). USEPA determined this compound to be a class B2 carcinogen, and determined the SF_o and the SF_i to be 9.1 $(mg/kg/day)^{-1}$. The primary target organs for this pesticide are the liver and kidneys, and USEPA determined the RfDo to be 1.3E-05 mg/kg/day).

2-Methylnaphthalene causes hemolysis with subsequent blocking of renal tubules by precipitated hemoglobin. Hepatic necrosis has been reported. Hemolysis only occurs in individuals with a hereditary deficiency of glucose-6-phosphate dehydrogenase in the red cells, which results in a low level of reduced glutathione and increased susceptibility to hemolysis by naphthalene metabolites. The oral RfD for 2-methylnaphthalene is 2E-02 mg/kg/day.

10.9.6.5 Risk Characterization

Surface Soil Pathways

Exposure to surface soil onsite was evaluated under residential and industrial (site worker) scenarios using the incidental ingestion and dermal contact exposure pathways. For noncarcinogenic contaminants evaluated for future site residents, hazard was computed separately to address child and adult exposure. Tables 10.9.18 and 10.9.19 present the computed carcinogenic risks and/or HQs associated with the incidental ingestion of site surface soils and dermal contact with them.

Hypothetical Site Residents

The ingestion ILCR is 5E-5 (based on the adult and child lifetime-weighted average) for AOC 698 surface soils. The dermal pathway ILCR is 1E-05. Arsenic and BEQs were the primary contributors to risk projection for both pathways, and heptachlor epoxide was a secondary contributor.

The ingestion HIs projected for the adult and child receptors are 0.07 and 0.6, respectively. The dermal pathway HIs were 0.02 for the adult resident receptor and 0.08 for the child resident receptor.

Table 10.9.18
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Surface Soil Ingestion
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganics							
Arsenic (As)	0.0003	1.5	0.048	0.45	2.5E-05	0.017	2.8E-06
Cadmium (Cd)	0.001	NA	0.0055	0.051	ND	0.0020	ND
Carcinogenic PAHs							
Benzo(a)pyrene equivalents	NA	7.3	ND	ND	2.3E-05	ND	2.6E-06
Pesticides							
Heptachlor Epoxide	1.3E-05	9.1	0.015	0.14	2.0E-06	0.0053	2.2E-07
SUM Hazard Index/ILCR			0.07	0.6	5E-05	0.02	6E-06

NOTES:
- NA Not available
- ND Not Determined due to lack of available information
- LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.
- ILCR Incremental Lifetime Cancer Risk

Table 10.9.19
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact With Surface Soil
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident Adult Hazard Quotient	Future Resident Child Hazard Quotient	Future Resident LWA ILCR	Current Worker Adult Hazard Quotient	Current Worker Adult ILCR
Inorganics								
Arsenic (As)	0.2	0.00006	7.5	0.0098	0.032	2.8E-06	0.0070	1.1E-06
Cadmium (Cd)	0.2	0.0002	NA	0.0011	0.0037	ND	0.0008	ND
Carcinogenic PAHs								
Benzo(a)pyrene equivalents	0.5	NA	14.6	ND	ND	1.0E-05	ND	4.2E-06
Pesticides								
Heptachlor epoxide	0.5	0.000007	18.2	0.012	0.040	9.0E-07	0.0086	3.7E-07
SUM Hazard Index/ILCR				0.02	0.08	1E-05	0.02	6E-06

NOTES:
NA Not available
ND Not determined due to lack of available information
LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
ILCR Incremental Lifetime Cancer Risk
- Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Hypothetical Site Workers

Site worker ILCRs are 6E-6 for the ingestion pathway and 6E-06 for the dermal contact pathway. Arsenic and BEQs were the primary contributors to risk estimates for both pathways.

Site worker HIs are 0.02 for the ingestion pathway and 0.02 for the dermal pathway.

Groundwater Pathways

Exposure to shallow groundwater onsite was evaluated under a residential scenario based on the results of all four sampling events. The exposure pathways were evaluated assuming the site groundwater will be used for potable and/or domestic purposes and that an unfiltered well, drawing from the corresponding water-bearing zone, will be installed. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately for child and adult receptors. Table 10.9.20 presents the risk and hazard for the ingestion pathway and Table 10.9.21 presents the risk and hazard for the inhalation pathway.

Hypothetical Site Residents

The residential scenario lifetime-weighted average ILCRs for the ingestion and inhalation pathways are 3E-05 and 7E-06, respectively. Benzene, alpha-BHC, and delta-BHC were the primary contributors to the ingestion pathway, and benzene was the sole contributor to the inhalation pathway.

The hazard indices for the adult and child resident are 0.04 and 0.09, respectively, for the ingestion pathway. The hazard indices for the adult and child resident are 0.3 and 0.6, respectively, for the inhalation pathway.

Table 10.9.20
Hazard Quotients and Incremental Lifetime Cancer Risks
Shallow Groundwater Ingestion
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident LWA ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Pesticides							
delta-BHC	NA	1.8	ND	ND	5.7E-06	ND	1.8E-06
Volatile Organics							
Benzene	NA	0.029	ND	ND	2.2E-06	ND	7.0E-07
SUM Hazard Index/ILCR			ND	ND	8E-06	ND	3E-06

NOTES:
- NA Not available
- ND Not Determined due to lack of available information
- LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.
- ILCR Incremental Lifetime excess Cancer Risk

Table 10.9.21
Hazard Quotients and Incremental Lifetime Cancer Risks
Inhalation of Groundwater VOC Resulting from Domestic or Process Use
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Chemical	Inhalation RfD Used (mg/kg-day)	Inhalation SF Used $(mg/kg\text{-}day)^{-1}$	Future Resident adult Hazard Quotient	Future Resident child Hazard Quotient	Future Resident LWA ILCR	Future Worker adult Hazard Quotient	Future Worker adult ILCR
Volatile Organics							
Benzene	0.00171	0.029	0.080	0.19	2.2E-06	0.029	7.0E-07
SUM Hazard Index/ILCR			0.08	0.2	2E-06	0.03	7E-07

NOTES:

- NA Not available
- ND Not determined due to lack of available information
- LWA Lifetime-weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A.
- ILCR Incremental Lifetime excess Cancer Risk

Hypothetical Site Workers

The site worker scenario ILCRs for the ingestion and inhalation pathways are 9E-06 and 2E-07, respectively. Benzene, alpha-BHC, and delta-BHC were the primary contributors for the ingestion pathway, and benzene was the sole contributor to the inhalation pathway.

The hazard indices for the ingestion and inhalation pathways are 0.01 and 0.09, respectively.

Current Site Workers

Shallow groundwater is not currently used as a potable water source for AOC 698 or other Zone K areas. In the absence of a completed exposure pathway, no threat to human health is posed by reported shallow groundwater contamination.

COCs Identified

Chemicals of concern were based on cumulative (all pathway) risk and hazard projected for this site on a medium-specific basis. USEPA has established a generally acceptable risk range of 1E-4 to 1E-6, and a hazard index threshold of 1.0 (unity). As recommended by SCDHEC, a COC is considered to be any chemical contributing to a cumulative risk level of at least 1E-6 and/or a cumulative hazard index exceeding 1.0, if its individual ILCR exceeds 1E-6 or its hazard quotient exceeds 0.1. For carcinogens, this approach is relatively conservative because a cumulative risk level of 1E-4 (and individual ILCR of 1E-6) is recommended by USEPA Region IV as the trigger for establishing COCs. The COC selection method presented was used to more comprehensively evaluate chemicals contributing to carcinogenic risk or noncarcinogenic hazard during remedial goal options development. Table 10.9.22 presents the COCs identified for AOC 698 surface soil and groundwater.

Table 10.9.22
Summary of Risk and Hazard-based COCs
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway		Future Resident Adult Hazard Quotient (HI)	Future Resident Child Hazard Quotient (HI)	Future Resident LWA ILCR	Current Site Worker Hazard Quotient	Current Site Worker ILCR	Identification of COCs	
Surface Soil	Incidental	**Inorganics**							
	Ingestion	Arsenic (As)	0.048	0.45	2.5E-05	0.017	2.8E-06	2	4
		Cadmium (Cd)	0.005	0.05	ND	0.0020	ND		
		Carcinogenic PAHs							
		Benzo(a)pyrene equivalents	ND	ND	2.3E-05	ND	2.6E-06	2	4
		Pesticides							
		Heptachlor epoxide	0.015	0.14	2.0E-06	0.0053	2.2E-07	2	
	Dermal	**Inorganics**							
		Arsenic (As)	0.010	0.032	2.8E-06	0.0070	1.1E-06	2	4
		Cadmium (Cd)	0.0011	0.0037	ND	0.0008	ND		
		Carcinogenic PAHs							
		Benzo(a)pyrene equivalents	ND	ND	1.0E-05	ND	4.2E-06	2	4
		Pesticides							
		Heptachlor Epoxide	0.012	0.040	9.0E-07	0.0086	3.7E-07		
Surface Soil Pathway Sum			0.09	0.7	6E-05	0.04	1E-05		
Groundwater Pathways	Ingestion	**Pesticides**							
		alpha-BHC	ND	ND	1.4E-05	ND	4.5E-06	2	4
		delta-BHC	ND	ND	5.7E-06	ND	1.8E-06	2	4
		Semivolatile Organics							
		2-Methylnaphthalene	0.040	0.093	ND	0.014	ND		
		Volatile Organics							
		Benzene	ND	ND	7.0E-06	ND	2.2E-06	2	4
	Inhalation	**Semivolatile Organics**							
		2-Methylnaphthalene	ND	ND	ND	ND	ND		
		Volatile Organics							
		Benzene	0.26	0.60	7.0E-06	0.092	2.2E-06	2	4
Groundwater Pathway Sum			0.3	0.7	3E-05	0.1	1E-05		
Sum of All Pathways			0.4	1	1E-04	0.1	2E-05		

Notes:
ND indicates not determined due to the lack of available risk information.
ILCR indicates incremental excess lifetime cancer risk
HI indicates hazard index
Identification of COCs
1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.
2- Chemical is a COC by virtue of projected future resident lifetime ILCR.
3- Ch[illegible] is a COC by virtue of projected site worker noncarcinogenic hazard.
4- Ch[illegible] is a COC by virtue of projected site worker ILCR.

Future Site Residents

Surface Soils

Arsenic, BEQs, and heptachlor epoxide were identified as soil pathway COCs based on their contributions to cumulative residential ILCR projections.

Future Site Workers

Arsenic and BEQs were identified as a soil pathway COC based on their contributions to ILCR projections for the site worker scenario.

The areal extent of the COCs identified in surface soil is briefly discussed below. Residential soil RBCs and background reference concentrations were compared to each reported COC concentration. Heptachlor epoxide was reported at concentrations exceeding its residential RBC in two surface soil samples (698SB002 and 698SB011). Arsenic exceeded its RBC in eight surface soil samples and its background reference value in five surface soil samples. Cadmium was detected in only one surface soil sample (698SB003) at a concentration exceeding its RBC. BEQs exceeded their RBCs in one of 12 surface soil samples (698SB020).

Shallow Groundwater

Benzene, alpha-BHC, and delta-BHC were identified as COC based on their contribution to ILCR projections under both residential and site worker scenarios. Benzene was reported at concentrations exceeding its RBC in all four sampling rounds collected from the AOC 698 monitoring well. Both alpha-BHC (fourth round) and delta-BHC (first-round) were each reported in one sampling round at a concentration exceeding their RBCs.

10.9.6.6 Risk Uncertainty

Characterization of Exposure Setting and Identification of Exposure Pathways

The potential for high bias is introduced through the exposure setting and pathway selection due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. The exposure assumptions made in the site worker scenario are highly protective and would tend to overestimate exposure.

Residential use of the site would not be expected, based on current site uses and the nature of surrounding buildings. If this area were to be used as a residential site, the surface soil conditions would likely change — the soils could be covered with landscaping soil and/or a house. Consequently, exposure to surface soil conditions as represented by samples collected during the CSI would not be likely under a true future residential scenario. These factors indicate that exposure pathways assessed in this HHRA would generally overestimate the risk and hazard posed to current site workers and future site residents.

Groundwater is not currently used at AOC 698 for potable or industrial purposes. A base-wide system provides drinking and process water to buildings throughout Zone K. This system is slated to remain in operation under the current base reuse plan. As a result, shallow groundwater would not be expected to be used under future site use scenarios, and associated pathways are not expected to be completed in the future.

Determination of Exposure Point Concentrations

The maximum detected soil and groundwater constituent concentrations were used as the exposure point concentrations for this site. Use of maximum detected concentrations represents conservative assumptions when they are applied as the EPC, such that it is unlikely for the maximum detected concentration to be exceeded by the true mean concentration.

Frequency of Detection and Spatial Distribution

Arsenic was detected in all eight surface soil samples with the highest concentration of 10.5 mg/kg reported in surface soil sample 698SB004. Otherwise arsenic was evenly distributed across the site at concentrations ranging from 0.98 to 10.5 mg/kg. These findings suggest that the risk and hazard has been overestimated based on the limited distribution of these COCs. Heptachlor epoxide was reported in only two surface soil samples at concentrations exceeding its RBC. The other two detections of heptachlor epoxide were well below its RBC. The limited extent of heptachlor epoxide indicates that associated risk estimates have likely been overestimated. Similarly, BEQs were only reported at detectable concentrations in two of 12 surface soil samples. As a result of the limited extent of BEQs impacts, associated risk has likely been overestimated.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment that would upwardly bias the risk and hazard estimates. Exposure pathway-specific sources of uncertainty are discussed below.

Soil

A conservative screening process was used to identify COPCs for AOC 698. The potential for eliminating CPSSs with the potential for cumulative HI greater than 1 was addressed for noncarcinogens through the use of RBCs that were reduced one order of magnitude. For carcinogens, the RBCs are based on a conservative target risk of 1E-06. Combining conservative RBCs with maximum detected concentrations minimizes the likelihood of a significant contribution to risk/hazard based on eliminated CPSSs. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration within 10% of its RBC.

Groundwater

The same conservative screening process used for soil is also used for groundwater. Of the CPSSs screened and eliminated from formal assessment, none was reported at a concentration within 10% of its RBC.

Groundwater is not currently used as a potable water source at AOC 698, nor is it used for this purpose at CNC or in the surrounding area. Municipal water is readily available. As previously mentioned, it is highly unlikely that the site will be developed as a residential area, and it is unlikely that a potable-use well would be installed onsite. If residences were constructed onsite and an unfiltered well were installed, it is probable that the salinity and dissolved solids would preclude this aquifer from being an acceptable potable water source.

10.9.6.7 Risk Summary

The risk and hazard posed by contaminants at AOC 698 were assessed for future site workers and future site residents under reasonable maximum exposure assumptions. For surface soils, the incidental ingestion and dermal contact pathways were assessed in this HHRA. For groundwater, the ingestion and inhalation pathways were assessed. Table 10.9.23 summarizes risk for each pathway/receptor group evaluated for AOC 698.

Soil — Residential Scenario

Residential soil pathway COCs identified for AOC 698 are arsenic and heptachlor epoxide. Figure 10.9.4 illustrates point risk estimates for AOC 698 based on soil exposure pathways under a future residential scenario. Table 10.9.24 summarizes the risk and hazard contribution of each COPC at each sample location. This point risk map is based on the unlikely assumption that a potential future site resident will be chronically exposed to specific points. Exposure to surface soil conditions is more likely the result of uniform exposure to the soil conditions of the entire site

Table 10.9.23
Summary of Risk and Hazard
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Medium	Exposure Pathway	HI (Adult)	HI (Child)	ILCR (LWA)	HI (Worker)	ILCR (Worker)
Surface Soil	Incidental Ingestion	0.07	0.6	5E-05	0.02	6E-06
	Dermal Contact	0.02	0.08	1E-05	0.016	6E-06
Sum of Soil Pathways		0.09	0.7	6E-05	0.04	1E-05
Groundwater	Ingestion	0.04	0.09	3E-05	0.01	9E-06
	Inhalation	0.3	0.6	7E-06	0.09	2E-06
Sum of Groundwater Pathway		0.3	0.7	3E-05	0.1	1E-05
Sum of All Pathways		0.4	1	1E-04	0.1	2E-05

Notes:
ILCR Indicates incremental lifetime cancer risk
HI Indicates hazard index

Table 10.9.24
Point Estimates of Risk and Hazard - Surface Soil Pathways
Residential Scenario
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Inde	%HI	Risk (E-06)	%Risk
698	B001	Arsenic (As)	6.7	MG/KG	0.3062	94.02	17.5004	100.00
698	B001	Cadmium (Cd)	0.71	MG/KG	0.0195	5.98	NA	
		Total			0.3257		17.5004	
698	B002	Arsenic (As)	2.45	MG/KG	0.1120	38.94	6.3994	70.61
698	B002	Cadmium (Cd)	0.435	MG/KG	0.0119	4.15	NA	
698	B002	Heptachlor epoxide	129	UG/KG	0.1637	56.91	2.6630	29.39
		Total			0.2876		9.0624	
698	B003	Arsenic (As)	4.8	MG/KG	0.2194	66.67	12.5376	100.00
698	B003	Cadmium (Cd)	4	MG/KG	0.1097	33.33	NA	
		Total			0.3291		12.5376	
698	B004	Arsenic (As)	10.5	MG/KG	0.4799	99.43	27.4260	100.00
698	B004	Cadmium (Cd)	0.1	MG/KG	0.0027	0.57	NA	
		Total			0.4827		27.4260	
698	B005	Arsenic (As)	0.98	MG/KG	0.0448	100.00	2.5598	100.00
		Total			0.0448		2.5598	
698	B006	Arsenic (As)	5.4	MG/KG	0.2468	97.09	14.1048	100.00
698	B006	Cadmium (Cd)	0.27	MG/KG	0.0074	2.91	NA	
		Total			0.2542		14.1048	
698	B007	Arsenic (As)	3.5	MG/KG	0.1600	100.00	9.1420	100.00
		Total			0.1600		9.1420	
698	B008	Arsenic (As)	1.4	MG/KG	0.0640	100.00	3.6568	100.00
		Total			0.0640		3.6568	
698	B009	No COPCs detected	ND	UG/KG	NA		NA	
698	B010	No COPCs detected	ND	UG/KG	NA		NA	
698	B011	Heptachlor epoxide	140	UG/KG	0.1776	100.00	2.8901	100.00
		Total			0.1776		2.8901	
698	B012	Heptachlor epoxide	2.2	UG/KG	0.0028	100.00	0.0454	100.00
		Total			0.0028		0.0454	
698	B013	Heptachlor epoxide	6.3	UG/KG	0.0080	100.00	0.1666	100.00
		Total			0.0080		0.1666	
698	B014	No COPCs detected	ND	UG/KG	NA		NA	
698	B015	No COPCs detected	ND	UG/KG	NA		NA	
698	B016	No COPCs detected	ND	UG/KG	NA		NA	
698	B017	No COPCs detected	ND	UG/KG	NA		NA	
698	B018	No COPCs detected	ND	UG/KG	NA		NA	
698	B019	Benzo(a)pyrene Equivalents	28.06	UG/KG	NA		0.0465	100.00
		Total			NA		0.0465	
698	B020	Benzo(a)pyrene Equivalents	2092.6	UG/KG	NA		34.6442	100.00
		Total			NA		34.6442	

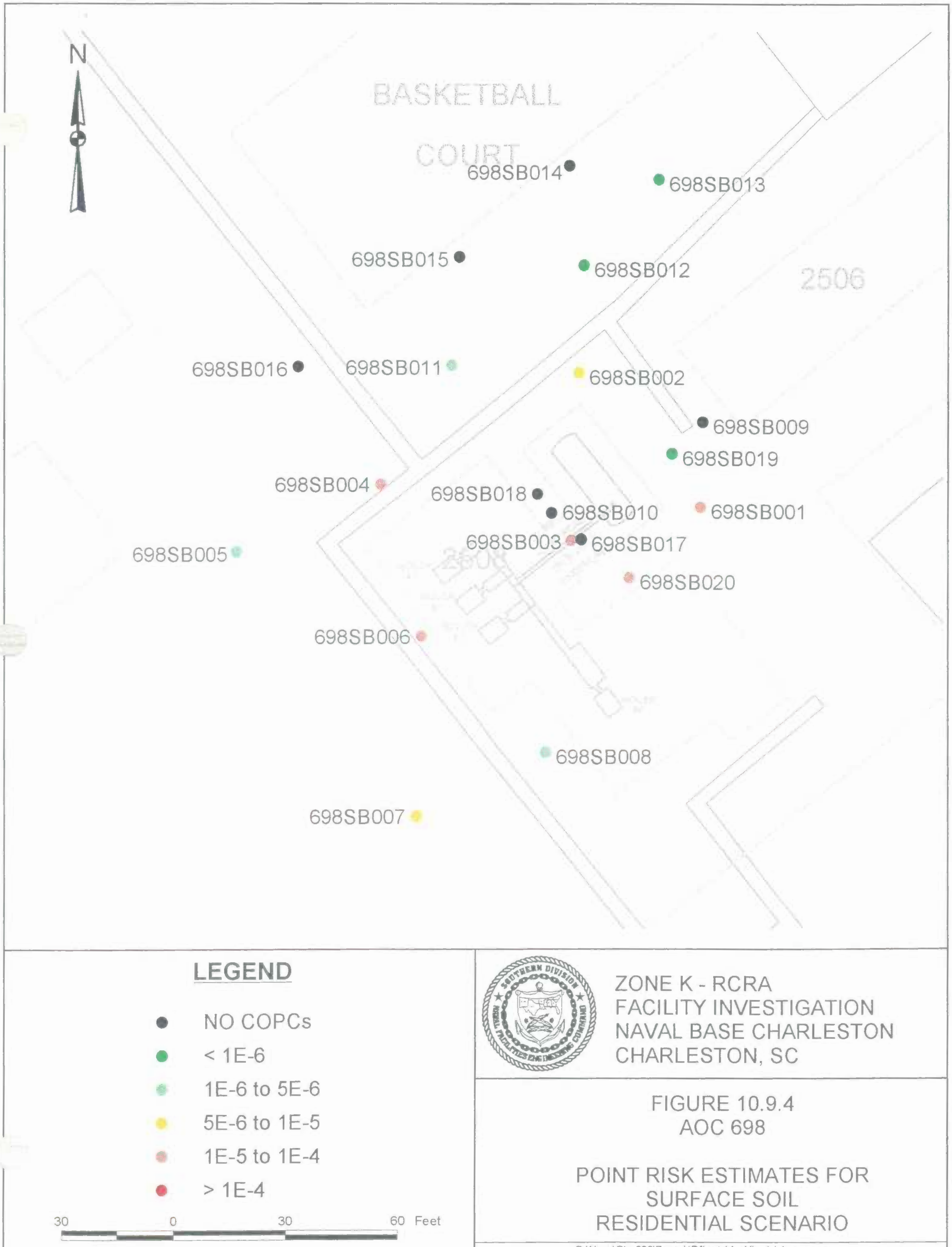


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FIGURE 10.9.4
AOC 698

POINT RISK ESTIMATES FOR
SURFACE SOIL
RESIDENTIAL SCENARIO

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(or exposure unit area) rather than specific points. Risk maps supplemented by the tables help the reader visualize how chemicals driving risk estimates are spatially distributed across the site.

Arsenic is the primary contributor to risk estimates above 1E-06 at eight of the 20 surface soil sample locations. Heptchlor epoxide was the risk estimate associated with surface soil locations 698SB002, 698SB011, 698SB012, and 698SB013. Risk estimates ranged from 5E-08 (698SB012) to 3E-05 (698SB020), with a mean risk of 7E-06 (assuming a de minimus risk of 1E-07 for sample locations where no COPCs were detected). Hazard index estimates ranged from 0.003 (698SB012) to 0.5 (698SB004).

Soil — Site Worker Scenario

Site worker soil pathway COCs identified for AOC 698 are arsenic and BEQs. Figure 10.9.5 illustrates point risk estimates for AOC 698 based on soil exposure pathways under a future industrial scenario. Table 10.9.25 summarizes the risk and hazard contribution of each COPC at each sample location.

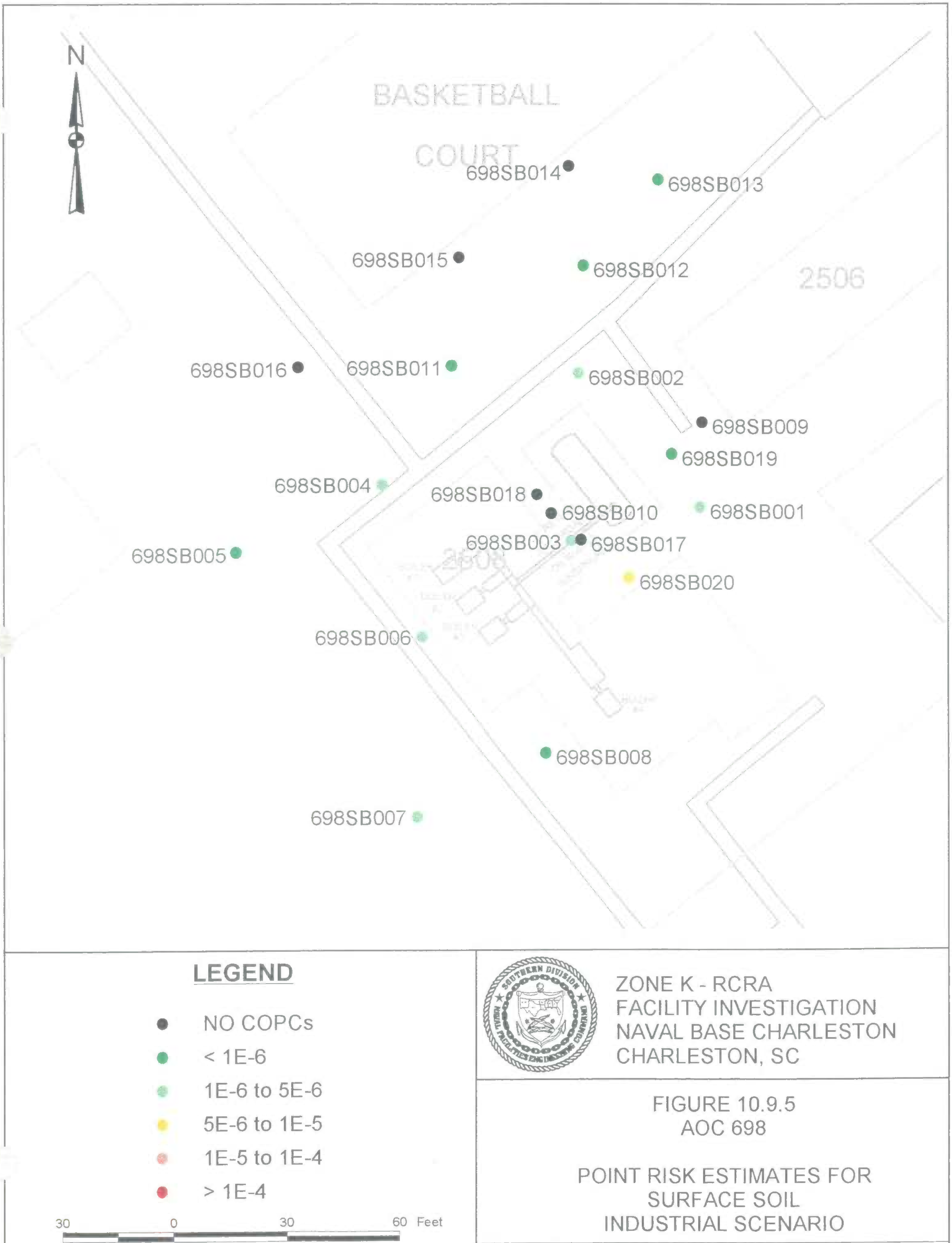
Arsenic is the primary contributor to risk estimates at eight of the 20 surface soil sample locations. BEQs are the primary contributors to risk estimates associated with surface soil sample locations 698SB019 and 698SB020. Risk estimates ranged from 9E-097 (698SB012) to 7E-06 (698SB020), with a mean risk of 1E-06. Hazard index estimates ranged from 0.0002 (698SB012) to 0.02 (698SB004).

Groundwater — Residential Scenario

Benzene, alpha-BHC, and delta-BHC were identified as groundwater pathway COCs. As shown in Table 10.9.26, benzene, alpha-BHC, and delta-BHC were the primary contributors to risk estimates associated with AOC 698 groundwater. Figures 10.9.6 and 10.9.7 illustrates point risk

Table 10.9.25
Point Estimates of Risk and Hazard - Surface Soil Pathways
Industrial Scenario
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
698	B001	Arsenic (As)	6.7	MG/KG	0.0154	94.02	2.4757	100.00
		Cadmium (Cd)	0.71	MG/KG	0.0010	5.98	NA	
		Total			0.0164		2.4757	
698	B002	Arsenic (As)	2.45	MG/KG	0.0056	29.57	0.9053	62.57
		Cadmium (Cd)	0.435	MG/KG	0.0006	3.15	NA	
		Heptachlor epoxide	129	UG/KG	0.0128	67.28	0.5415	37.43
		Total			0.0190		1.4468	
698	B003	Arsenic (As)	4.8	MG/KG	0.0110	66.67	1.7736	100.00
		Cadmium (Cd)	4	MG/KG	0.0055	33.33	NA	
		Total			0.0166		1.7736	
698	B004	Arsenic (As)	10.5	MG/KG	0.0241	99.43	3.8798	100.00
		Cadmium (Cd)	0.1	MG/KG	0.0001	0.57	NA	
		Total			0.0243		3.8798	
698	B005	Arsenic (As)	0.98	MG/KG	0.0023	100.00	0.3621	100.00
		Total			0.0023		0.3621	
698	B006	Arsenic (As)	5.4	MG/KG	0.0124	97.09	1.9953	100.00
		Cadmium (Cd)	0.27	MG/KG	0.0004	2.91	NA	
		Total			0.0128		1.9953	
698	B007	Arsenic (As)	3.5	MG/KG	0.0080	100.00	1.2933	100.00
		Total			0.0080		1.2933	
698	B008	Arsenic (As)	1.4	MG/KG	0.0032	100.00	0.5173	100.00
		Total			0.0032		0.5173	
698	B009	No COPCs detected			NA		NA	
698	B010	No COPCs detected			NA		NA	
698	B011	Heptachlor epoxide	140	UG/KG	0.0139	100.00	0.5876	100.00
		Total			0.0139		0.5876	
698	B012	Heptachlor epoxide	2.2	UG/KG	0.0002	100.00	0.0092	100.00
		Total			0.0002		0.0092	
698	B013	Heptachlor epoxide	6.3	UG/KG	0.0006	100.00	0.0264	100.00
		Total			0.0006		0.0264	
698	B014	No COPCs detected			NA		NA	
698	B015	No COPCs detected			NA		NA	
698	B016	No COPCs detected			NA		NA	
698	B017	No COPCs detected			NA		NA	
698	B018	No COPCs detected			NA		NA	
698	B019	Benzo(a)pyrene equivalents	28.06	UG/KG	NA		0.0094	100.00
		Total			NA		0.0094	
698	B020	Benzo(a)pyrene equivalents	2092.6	UG/KG	NA		7.0461	100.00
		Total			NA		7.0461	



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CHARLESTON, SC

FIGURE 10.9.5
AOC 698

POINT RISK ESTIMATES FOR
SURFACE SOIL
INDUSTRIAL SCENARIO

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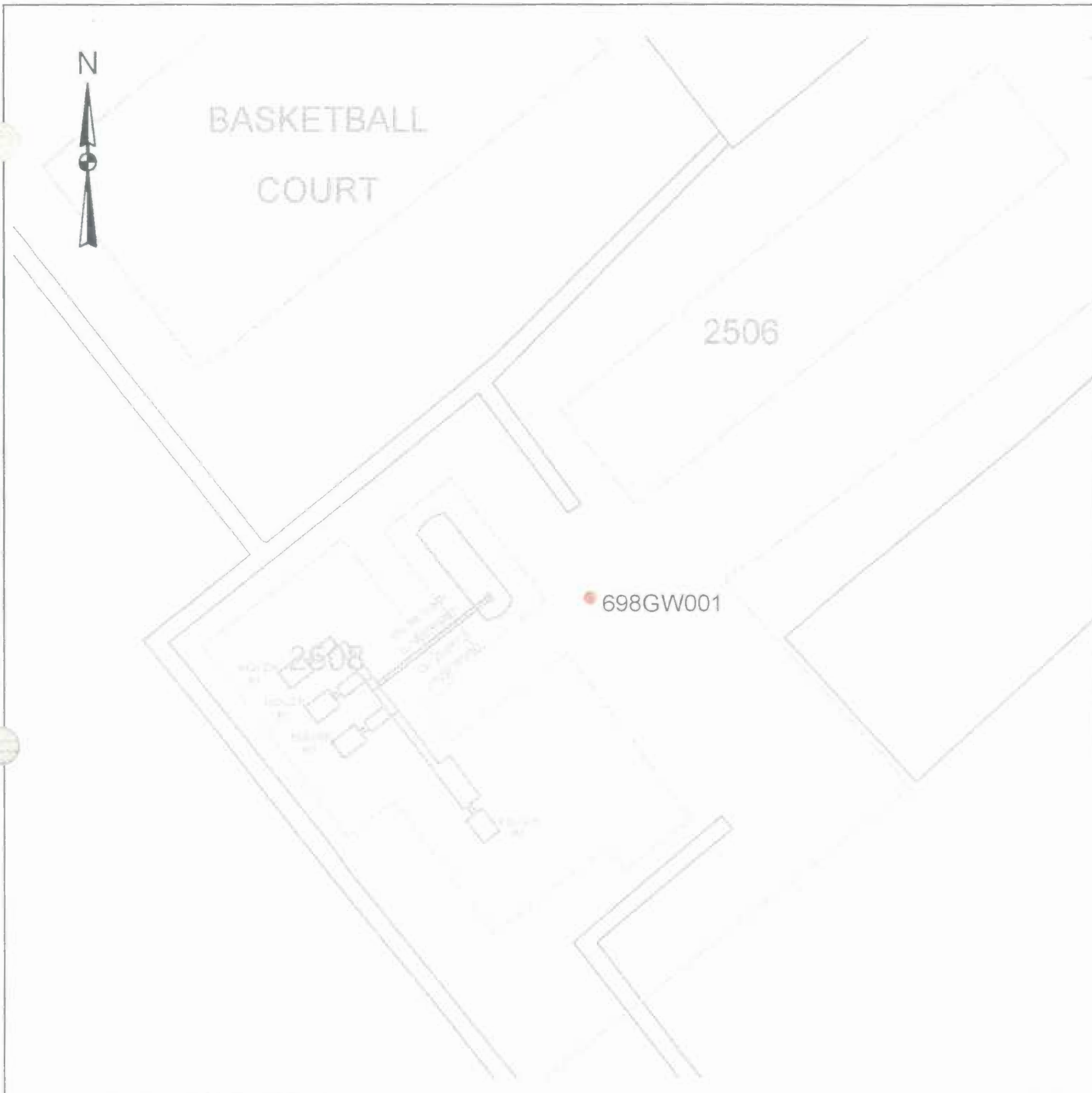

LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

30 0 30 60 Feet

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CHARLESTON, SC

FIGURE 10.9.6
AOC 698

POINT RISK ESTIMATES FOR
GROUNDWATER
RESIDENTIAL SCENARIO

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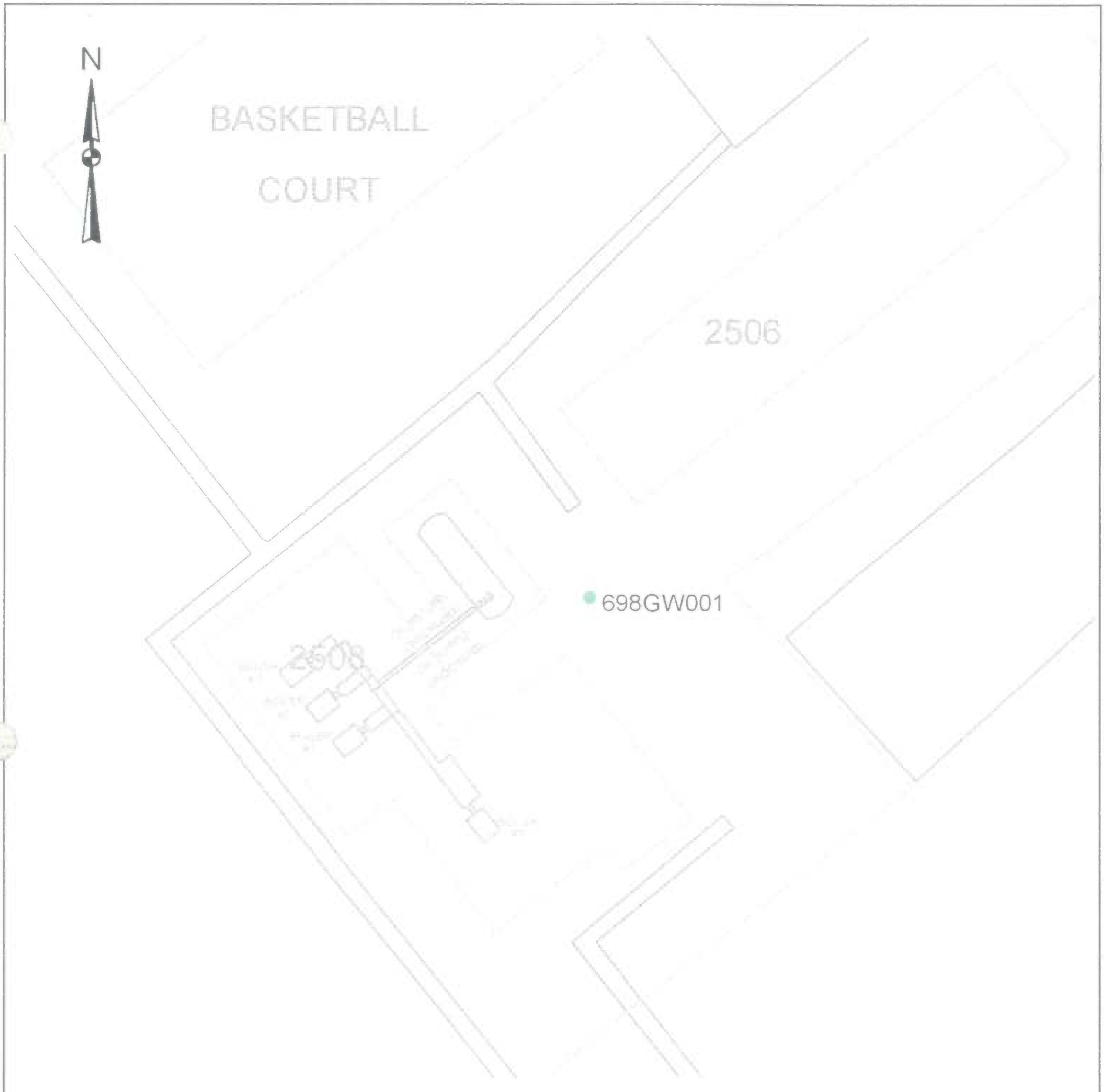

LEGEND

- NO COPCs
- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0

30 0 30 60 Feet

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FIGURE 10.9.7
AOC 698

POINT HAZARD ESTIMATES FOR
GROUNDWATER
RESIDENTIAL SCENARIO

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Table 10.9.26
Point Estimates of Risk and Hazard - Groundwater Pathways
Residential Scenario
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Round	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
698	G001	01	Benzene	5	UG/L	0.3738	90.00	4.3131	17.98
			delta-BHC	0.21	UG/L	NA		19.6767	82.02
			2-Methylnaphthalene	26	UG/L	0.0416	10.00	NA	
			Total			0.4154		23.9898	
698	G001	02	Benzene	16	UG/L	1.1963	97.97	13.8020	100.00
			2-Methylnaphthalene	29	UG/L	0.0247	2.03	NA	
			Total			1.2210		13.8020	
698	G001	03	Benzene	7	UG/L	0.5234	98.55	6.0384	100.00
			2-Methylnaphthalene	9	UG/L	0.0077	1.45	NA	
			Total			0.5311		6.0384	
698	G001	04	Benzene	6	UG/L	0.4486	97.95	5.1757	26.91
			alpha-BHC	0.15	UG/L	NA		14.0548	73.09
			2-Methylnaphthalene	11	UG/L	0.0094	2.05	NA	
			Total			0.4580		19.2305	

and hazard estimates for AOC 698 based on groundwater exposure pathways under a future residential scenario. Groundwater risk estimates remained relatively stable over each of the four sampling rounds, with point risk estimates ranging from 6E-06 to 2E-05. Hazard indices exceeded unity during the second-round primarily due to concentrations of benzene reported in that sample.

Groundwater — Site Worker Scenario

Benzene, alpha-BHC, and delta-BHC were identified as groundwater pathway COCs. As shown in Table 10.9.27, benzene, alpha-BHC, and delta-BHC were the primary contributors to risk estimates associated with AOC 698 groundwater. Figure 10.9.8 illustrates point risk and hazard estimates for AOC 698 based on groundwater exposure pathways under an industrial scenario. Groundwater risk estimates remained relatively stable over each of the four sampling rounds, with point risk estimates ranging from 2E-06 to 1E-05. Hazard indices did not exceed unity during any of the sampling rounds.

10.9.6.8 Remedial Goal Options

Soil

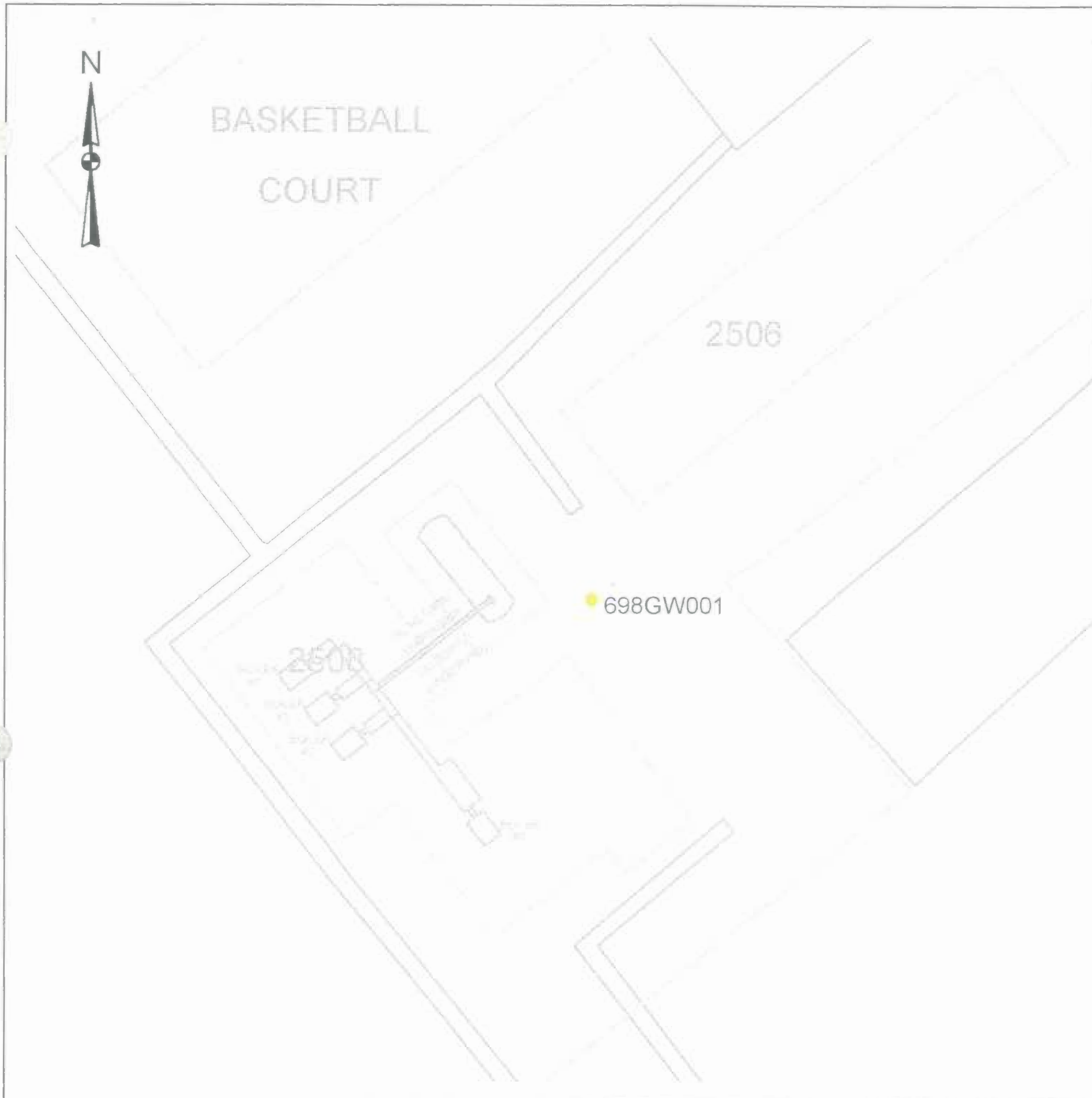
RGOs for carcinogens were based on the lifetime-weighted average site resident or site worker as presented in Table 10.9.28 for surface soils. Hazard-based RGOs were calculated based on the hypothetical child resident or site worker, as noted in the table.

Groundwater

Groundwater RGOs based on the site resident scenario are shown in Table 10.9.29.

10.9.7 Corrective Measures Considerations

For AOC 698, the upper and lower soil intervals and shallow groundwater were investigated. In all, 20 surface and 16 subsurface soil samples were collected. One groundwater monitoring well was sampled at the site. Based on the analytical results and the human health risk assessment,



LEGEND

- NO COPCs
- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4

30 0 30 60 Feet

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FIGURE 10.9.8
AOC 698

POINT RISK ESTIMATES FOR
GROUNDWATER
INDUSTRIAL SCENARIO

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Table 10.9.27
Point Estimates of Risk and Hazard - Groundwater Pathways
Industrial Scenario
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Site	Location	Round	Parameter	Concentration	Units	Hazard Index	%HI	Risk (E-06)	%Risk
698	G001	01	Benzene	5	UG/L	0.0858	100.00	1.5201	14.12
			delta-BHC	0.21	UG/L	NA		9.2466	85.88
			Total			0.0858		10.7667	
698	G001	02	Benzene	16	UG/L	0.2747	95.09	4.8644	100.00
			2-Methylnaphthalene	29	UG/L	0.0142	4.91	NA	
			Total			0.2888		4.8644	
698	G001	03	Benzene	7	UG/L	0.1202	96.47	2.1282	100.00
			2-Methylnaphthalene	9	UG/L	0.0044	3.53	NA	
			Total			0.1246		2.1282	
698	G001	04	Benzene	6	UG/L	0.1030	95.03	1.8242	21.64
			alpha-BHC	0.15	UG/L	NA		6.6047	78.36
			2-Methylnaphthalene	11	UG/L	0.0054	4.97	NA	
			Total			0.1084		8.4289	

Table 10.9.28
Remedial Goal Options for Soil
AOC 698
Charleston Naval Complex, Zone K
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Inorganics										
Arsenic (As)	1.5	0.0003	10.5	66	22	2.2	0.38	3.8	38	3
Carcinogenic PAHs										
Benzo(a)pyrene equivalents	7.3	NA	2.03	ND	ND	ND	0.060	0.60	6.0	NA
Pesticides										
Heptachlor epoxide	9.1	1.3E-05	0.14	2.4	0.79	0.079	0.048	0.48	4.8	NA

Worker-Based Remedial Goal Options

Chemical	Slope Factor $(mg/kg\text{-}day)^{-1}$	Reference Dose (mg/kg-day)	EPC mg/kg	Hazard-Based Remedial Goal Options **3** mg/kg	**1** mg/kg	**0.1** mg/kg	Risk-Based Remedial Goal Options **1E-06** mg/kg	**1E-05** mg/kg	**1E-04** mg/kg	Background Concentration mg/kg
Inorganics										
Arsenic (As)	1.5	0.0003	10.5	1305	435	43	2.7	27	271	3
Carcinogenic PAHs										
Benzo(a)pyrene equivalents	7.3	NA	2.0	ND	ND	ND	0.30	3.0	30	NA

NOTES:

EPC Exposure point concentration
NA Not applicable
ND Not determined
- Remedial goal options were based on the residentia[illegible]ite worker lifetime weighted average for carcinogens and the child resident or site worke[illegible]noncarcinogens

Table 10.9.29
Remedial Goal Options - Shallow Groundwater
AOC 698
Charleston Naval Complex, ZoneK
Charleston, South Carolina

Residential-Based Remedial Goal Options

Chemical	Oral SF $(mg/kg\text{-}day)^{-1}$	Oral RfD (mg/kg-day)	EPC mg/l	Hazard-Based Remedial Goal Options **0.1** mg/l	**1.0** mg/l	**3** mg/l	Risk-Based Remedial Goal Options **1E-06** mg/l	**1E-05** mg/l	**1E-04** mg/l	MCL mg/l	Background Concentration mg/l
Pesticides											
delta-BHC	1.8	NA	0.00021	ND	ND	ND	0.000037	0.00037	0.0037	NA	NA
Volatile Organics											
Benzene	0.029	NA	0.005	0.0027	0.027	0.080	0.0011	0.011	0.11	0.005	NA

NOTES:
EPC Exposure point concentration
NA Not applicable
ND Not determined
- Remedial goal options were based on the residential lifetime weighted average for carcinogens and the child resident for noncarcinogens

COCs requiring further evaluation through the CMS process were identified for the upper soil interval and groundwater.

Arsenic, BEQs, and heptachlor epoxide were identified as COCs in the upper soil interval. Arsenic exceeded its RBC (0.43 mg/kg) in all eight surface soil samples. Heptachlor epoxide was detected in one soil sample (698SB002) above its RBC. BEQs exceeded its RBC in one sample (698SB020). The soil pathway cumulative residential exposure risk is 6E-05 and the cumulative HI is 0.7 (resident child). Both are between USEPA's acceptable range of 1E-06 and 1E-04 for risk and 3 and 0.1 for HI.

Residential risk-based remedial goals for surface soil set for arsenic, BEQs, and heptachlor were 0.38, 0.060, and 0.048 mg/kg, respectively, based on a target risk of 1E-06. Potential corrective measures, in addition to no further action for soil, and respective COCs are presented in Table 10.9.30.

Benzene, alpha-BHC, and delta-BHC were identified as the COCs in the groundwater sample at AOC 698. The cumulative residential-based risk associated with these compounds is 3E-05 which is between USEPA's acceptable range of 1E-06 and 1E-04. The cumulative residential-based HI was 0.700. Benzene's residential-based remedial goal option for the shallow groundwater is 0.0011 mg/L, alpha-BHC's is 0.000011 mg/L, and delta-BHC's is 0.000037 mg/L. Potential corrective measures, in addition to no further action for shallow groundwater, and respective COCs are presented in Table 10.9.30.

Table 10.9.30
Potential Corrective Measures for AOC 698

Medium	Compounds	Potential Corrective Measures
Soil	Arsenic, BEQs, and heptachlor epoxide	a) No Action b) Intrinsic rededication and monitoring c) Containment by capping d) Excavation and landfill, if RCRA-nonhazardous waste e) Insitu, chemical and physical treatment f) Exsitu, chemical and physical treatment
Shallow Groundwater	Benzene, alpha-BHC, and delta-BHC	a) No Action b) Intrinsic remediation and monitoring c) Exsitu, chemical and physical treatment

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10.10 SWMU 166, Automotive Service Shop, Naval Annex

The RFI report for SWMU 166, was submitted as an addendum along with SWMU 185, Sewer System and Former Septic Tank System in November 1998. The revised Section 10.10 will be included with this Final RFI report following completion of the SWMU 166 investigation and review of the addendum.

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10.11 Background Sampling

Soil and groundwater samples were collected to characterize background conditions across Zone K as required by the final RFI work plan (E/A&H, September 1996). Figure 10.11.1 identifies background sample locations at Naval Annex. Figure 10.11.2 identifies background sample locations at Clouter Island.

10.11.1 Soil Sampling and Analysis

The final RFI work plan proposed nine upper interval soil samples and nine lower interval samples to be collected from locations at the Naval Annex and four upper interval soil samples and four lower interval soil samples to be collected from locations at Clouter Island. One of the Clouter Island soil sampling locations was in the Dredge Spoil Area. All of the Naval Annex samples and all of the upper interval samples at Clouter Island were collected. Due to shallow depth to groundwater, only one of the lower interval samples proposed at Clouter Island was collected.

Naval Annex samples were analyzed for the standard suite of parameters: VOCs, SVOCs, metals, cyanide, pesticides, PCBs, and TPH. Clouter Island samples were analyzed for the Appendix IX list of analytical parameters plus explosives. Table 10.11.1 summarizes soil sampling and analysis of the background soil samples for Naval Annex and Clouter Island.

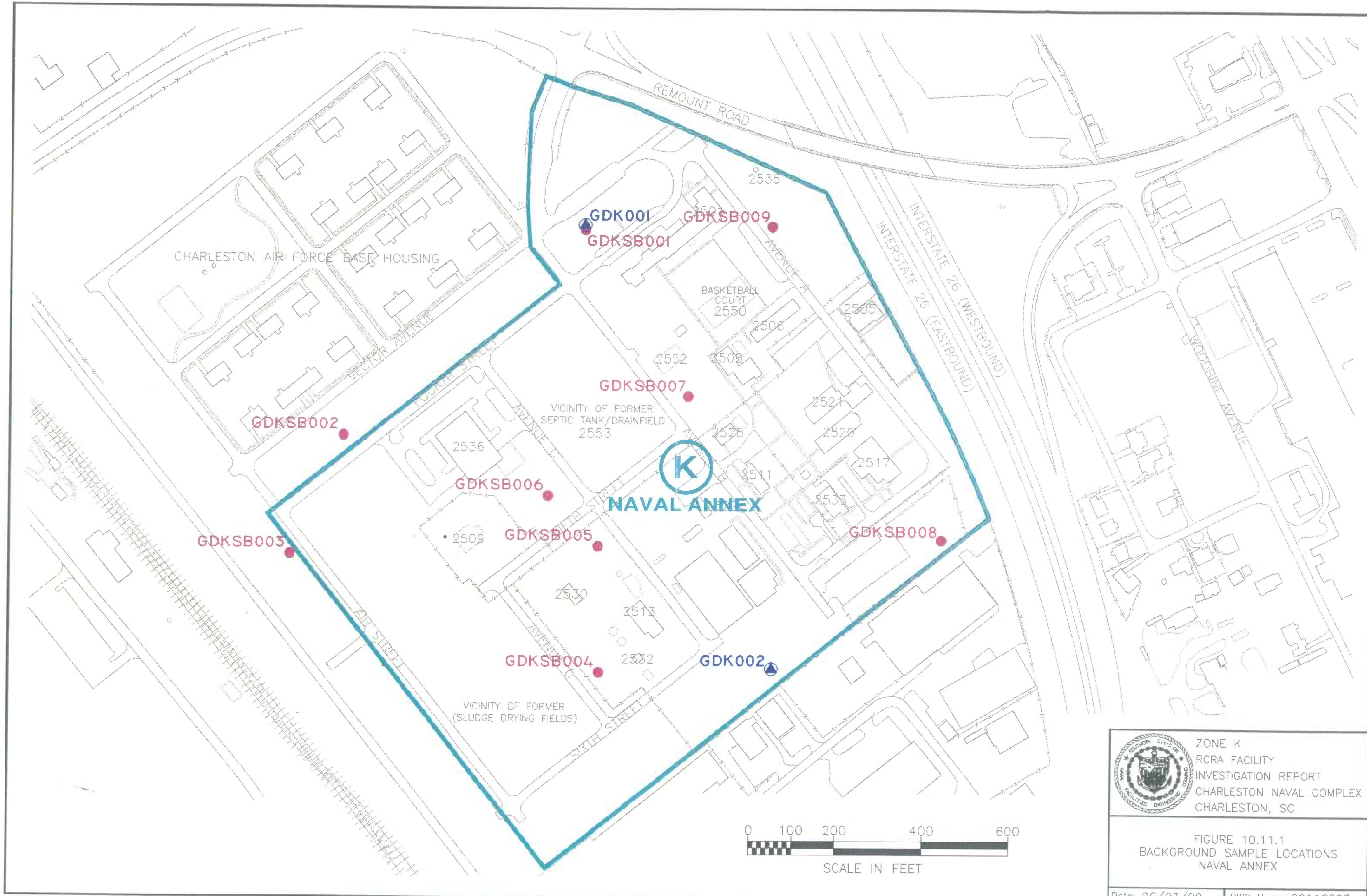
10.11.2 Nature and Extent of Chemicals in Soil

Organic compound analytical results for Naval Annex are summarized in Table 10.11.2; for Clouter Island, the organic compound analytical results are summarized in Table 10.11.3. Inorganic analytical results for Naval Annex are summarized in Table 10.11.4; for Clouter Island, the inorganic analytical results are summarized in Table 10.11.5. Appendix F is a complete analytical data report for all background samples collected in Zone K.

Table 10.11.1
Soil Sampling Summary

Interval	Samples Proposed	Samples Collected	Sample Analyses	Comments
Upper	9 (Naval Annex)	9 (Naval Annex)	Standard Suite and TPH	None
	4 (Clouter Island)	4 (Clouter Island)	Appendix IX and explosives	
Lower	9 (Naval Annex)	9 (Naval Annex)	Standard Suite and TPH	Three lower interval samples were not collected due to shallow depth to groundwater (Clouter Island).
	4 (Clouter Island)	1 (Clouter Island)	Appendix IX and explosives	

Notes:
Standard Suite = VOCs, SVOCs, metals, cyanide, pesticides, and PCBs.
Appendix IX = Standard Suite plus hex-chrome, OP pesticides, dioxins, and herbicides at DQO Level IV



ZONE K
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC

FIGURE 10.11.1
BACKGROUND SAMPLE LOCATIONS
NAVAL ANNEX

Date: 06/03/99 | DWG Name: 2911C085

00149TB192


LEGEND:
GDKSBCL2 SOIL SAMPLE LOCATION
GDKCLI SHALLOW MONITORING WELL LOCATION
N
GDKCLI
GDKSBCLI
108
CLOUTER ISLAND
GDKSBCL2
K
CLOUTER ISLAND
GDKSBCL3
117
AOC 694
AOC 693
COOPER RIVER
GDKSBCL4
102
0 50 100 200 300
SCALE IN FEET
103
AOC 695
ZONE K
RCRA FACILITY
INVESTIGATION REPORT
CHARLESTON NAVAL COMPLEX
CHARLESTON, SC
FIGURE 10.11.2
BACKGROUND SAMPLE LOCATIONS
CLOUTER ISLAND
Date: 06/03/99
DWG Name: 2911C086

Table 10.11.2
Background Samples from Naval Annex
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBCs or SSL
Semivolatiles (μg/kg)						
18 total samples collected, 9 upper interval samples, 9 lower interval samples, 2 lower interval duplicates						
Butylbenzylphthalate	Upper	0/9	ND	NA	1,600,000	NA
	Lower	1/9	91	NA	930,000	0
bis(2-Ethylhexyl)phthalate	Upper	0/9	ND	NA	46,000	NA
	Lower	1/9	88	NA	1,800,000	0
Fluoranthene	Upper	1/9	270	NA	310,000	0
	Lower	0/9	ND	NA	2,100,000	NA
Phenanthrene	Upper	1/9	390	NA	160,000	NA
	Lower	0/9	ND	NA	660,000	NA
Phenol	Upper	1/9	190	NA	4,700,000	0
	Lower	0/9	ND	NA	50,000	NA
Pyrene	Upper	1/9	160	NA	230,000	0
	Lower	0/9	ND	NA	2,100,000	NA
Pesticides/PCBs (μg/kg)						
18 total samples collected, 9 upper interval samples, 9 lower interval samples, 2 lower interval duplicates						
4,4'-DDD	Upper	1/9	5.08	NA	2,700	0
	Lower	0/9	ND	NA	8,000	NA
4,4'-DDE	Upper	9/9	4.16 - 40.9	17.6	1,900	0
	Lower	0/9	ND	NA	27,000	NA
4,4'-DDT	Upper	9/9	5.28 - 41.1	16.0	1,900	0
	Lower	0/9	ND	NA	16,000	NA
TPH - Diesel Range Organics (μg/kg)						
18 total samples collected, 9 upper interval samples, 9 lower interval samples, 2 lower interval duplicates						
Diesel	Upper	8/9	8,760 - 74,400	21,700	100,000*	0
	Lower	2/9	11,200 - 24,900	18,000	100,000	0
Dioxin (ng/kg)						
(2 duplicate samples analyzed for APX9 parameters)						
TCDD TEQs	Upper	0/0	NA	NA	4.3	NA
	Lower	2/2	0.68 - 0.94	0.48	1,600	0
1234678-HpCDD	Upper	0/0	NA	NA	0.43	NA
	Lower	1/2	13	NA	110,000	0
OCDD	Upper	0/0	NA	NA	4.3	NA
	Lower	2/2	6.76 - 811	409	1,100,000	0

Notes:
* – Charleston Naval Complex project screening level
ND – Not detected/not determined
NA – Not applicable/not available/not analyzed
NL – Not listed

Table 10.11.3
Background Samples from Clouter Island
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBCs or SSL
Semivolatiles (μg/kg)						
4 total samples collected, 3 upper interval samples, 1 lower interval sample						
bis(2-Ethylhexyl)phthalate	Upper	1/3	140	NA	46,000	0
	Lower	0/1	NA	NA	1,800,000	NA
Fluoranthene	Upper	1/3	240	NA	310,000	0
	Lower	0/1	NA	NA	2,100,000	NA
Pyrene	Upper	1/3	160	NA	230,000	0
	Lower	0/1	NA	NA	2,100,000	NA
Benzo(a)anthracene	Upper	1/3	110	NA	870	0
	Lower	0/1	NA	NA	800	NA
Chrysene	Upper	1/3	96	NA	87,000	0
	Lower	0/1	NA	NA	80,000	NA
Benzo(k)fluoranthene	Upper	1/1	200	NA	8,700	0
	Lower	0/1	NA	NA	25,000	NA
Pesticides/ PCBs (μg/kg)						
4 Total Samples Collected, 3 Upper Interval Samples, 1 Lower Interval Sample						
Heptachlor Epoxide	Upper	1/3	24	NA	70	0
	Lower	0/1	NA	NA	330	NA
4,4'-DDT	Upper	1/3	33.2	NA	1,900	0
	Lower	0/1	NA	NA	16,000	NA
Aroclor-1260	Upper	1/3	64.3	NA	320	0
	Lower	0/1	NA	NA	1,000	NA
Dioxin (ng/kg)						
4 total samples collected, 3 upper interval samples, 1 lower interval sample						
TCDD TEQs	Upper	3/3	0.047 - 3.2	1.1	4.3	0
	Lower	0/1	0.022	NA	1,600	0
1234678-HpCDD	Upper	3/3	1.2 - 88	30.5	430	0
	Lower	1/1	1.27	NA	110,000	0
1234678-HpCDF	Upper	3/3	0.68 - 11.7	4.7	430	0
	Lower	0/1	NA	NA	54,000	NA
1234789-HpCDF	Upper	1/3	0.381	NA	430	0
	Lower	0/1	NA	NA	54,000	NA
123478-HxCDF	Upper	1/3	3.62	NA	43	0
	Lower	0/1	NA	NA	220,000	NA

Table 10.11.3
Background Samples from Clouter Island
Organics Detected In Soil

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	RBC (upper) SSL (lower)	Number of Samples Exceeding RBCs or SSL
123678-HxCDD	Upper	1/3	6.8	NA	43	0
	Lower	0/1	NA	NA	4,100	NA
123789-HxCDD	Upper	1/3	5.46	NA	43	0
	Lower	0/1	NA	NA	4,100	NA
OCDD	Upper	3/3	13.6 - 613	217	4,300	0
	Lower	1/1	9.37	NA	1,100,000	0
OCDF	Upper	2/3	1.25 - 25.1	13.2	4,300	0
	Lower	0/1	NA	NA	540,000	NA

Note:
NA - Not applicable/not available/not analyzed

Table 10.11.4
Naval Annex Background Samples
Inorganics Detected In Soil (mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC(upper) SSL(lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Metals							
18 total samples collected, 9 upper sample interval, 9 lower sample interval, 2 duplicates from lower sample interval							
Aluminum	Upper	9/9	4,050 - 8,320	5,578	11,200	7,800	0
	Lower	9/9	3,090 - 12,000	5,270	10,500	560,000	0
Antimony	Upper	1/9	0.59	NA	0.45	3.1	0
	Lower	0/9	NA	NA	NA	2.7	NA
Arsenic	Upper	9/9	0.6 - 2.5	1.5	3	0.43[a]	0
	Lower	9/9	0.34 - 3.1	1.0	1.98	15	0
Barium	Upper	9/9	6.6 - 20	12.8	25.6	550	0
	Lower	9/9	1.8 - 7.2	3.4	6.83	820	0
Beryllium	Upper	5/9	0.06 - 0.32	0.13	0.17	16	0
	Lower	6/9	0.03 - 0.20	0.08	0.12	32	0
Cadmium	Upper	1/9	0.08	NA	0.13	7.8	0
	Lower	0/9	NA	NA	NA	4	NA
Calcium	Upper	9/9	275 - 2,960	934	NA	NL	NA
	Lower	3/9	50.1 - 54.0	52.6	NA	NL	NA
Chromium	Upper	9/9	2.8 - 6.3	4.2	8.4	23	0
	Lower	9/9	2.4 - 8.5	4.4	8.76	19	0
Cobalt	Upper	3/9	0.16 - 0.46	0.27	0.34	470	0
	Lower	4/9	0.4 - 1.0	0.58	0.62	990	0
Copper	Upper	6/9	0.9 - 4.8	2.6	3.86	310	0
	Lower	3/9	0.23 - 0.51	0.33	0.34	5600	0
Iron	Upper	9/9	1,200 - 7,990	3,530	7,060	2,300	1
	Lower	9/9	795 - 10,900	2,570	5,130	NL	NA
Lead[b]	Upper	9/9	8.9 - 259	46.4	39.6	400	0
	Lower	9/9	2.5 - 4.4	3.2	6.43	400*	0

Table 10.11.4
Naval Annex Background Samples
Inorganics Detected In Soil (mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC(upper) SSL(lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Magnesium	Upper	9/9	65.6 - 251	136	NA	NL	NA
	Lower	9/9	28.1 - 225	85.4	NA	NL	NA
Manganese	Upper	9/9	3.2 - 45	13	26.4	160	0
	Lower	9/9	1.5 - 6.8	3.0	5.93	480	0
Nickel	Upper	5/9	0.39 - 2.0	1.4	1.7	160	0
	Lower	8/9	0.23 - 4.7	1.5	2.64	65	0
Potassium	Upper	6/9	42.2 - 112	69.1	NA	NL	NA
	Lower	2/9	78.2 - 90.7	84.4	NA	NL	NA
Selenium	Upper	3/9	0.63 - 0.71	0.68	0.84	39	0
	Lower	1/9	0.51	NA	0.52	2.6	0
Silver	Upper	2/9	0.24 - 0.88	0.56	0.44	39	0
	Lower	2/9	0.41 - 0.57	0.49	0.42	17	0
Sodium	Upper	6/9	11 - 21.1	15.5	NA	NL	NA
	Lower	4/9	9.9 - 26.1	17.3	NA	NL	NA
Tin	Upper	3/9	10.5 - 32	18.4	19.4	4,700	0
	Lower	0/9	NA	NA	NA	5,500	NA
Vanadium	Upper	9/9	5.3 - 12.5	7.9	15.8	55	0
	Lower	9/9	3.5 - 15.7	6.1	12.2	3,000	0
Zinc	Upper	1/9	23.8	NA	14.8	2,300	0
	Lower	0/9	NA	NA	NA	6,200	NA

Notes:
a = RBC for arsenic as a carcinogen
b = An RBC for lead is not available. The USEPA residential soil cleanup level was used for comparison (OSWER Directive 9355.4-12).
* = SSL value not based on target leachate concentration
NA = Not available/not applicable/not analyzed
NL = Not listed

Table 10.11.5
Clouter Island Background Samples
Inorganics Detected In Soil (mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Metals							
4 Total Samples Collected, 3 Upper Interval Samples, 1 Lower Interval Sample							
Aluminum	Upper	3/3	5,020 - 24,700	16,100	32,100	7,800	0
	Lower	1/1	14,200	NA	NA	560,000	0
Antimony	Upper	3/3	0.48 - 2.2	1.1	2.16	3.1	0
	Lower	0/1	NA	NA	NA	2.7	NA
Arsenic	Upper	3/3	7.2 - 13.8	11.5	23	0.43[a]	0
	Lower	1/1	13.7	NA	NA	15	0
Barium	Upper	3/3	16.5 - 51.3	33.6	67.1	550	0
	Lower	1/1	24.1	NA	NA	820	0
Beryllium	Upper	3/3	0.31 - 0.99	0.68	1.35	16	0
	Lower	1/1	0.62	NA	NA	32	0
Cadmium	Upper	2/3	0.29 - 0.42	0.36	0.55	7.8	0
	Lower	0/1	NA	NA	NA	4	NA
Calcium	Upper	3/3	45,700 - 59,000	50,600	NA	NL	NA
	Lower	1/1	18,200	NA	NA	NL	NA
Chromium	Upper	3/3	21.3 - 45.9	34.6	69.1	12,000	0
	Lower	1/1	25.7	NA	NA	1E+06	0
Cobalt	Upper	3/3	0.35 - 4.5	2.9	5.7	470	0
	Lower	1/1	3.1	NA	NA	990	0
Copper	Upper	3/3	39.8 - 94.5	59.5	119	310	0
	Lower	1/1	22.2	NA	NA	5600	0
Iron	Upper	3/3	10,400 - 23,400	17,600	35,200	2,300	0
	Lower	1/1	17,200	NA	NA	NL	NA

Table 10.11.5
Clouter Island Background Samples
Inorganics Detected In Soil (mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range	Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Lead[b]	Upper	3/3	37.7 - 70.8	49.1	98.3	400	0
	Lower	1/1	18.2	NA	NA	400*	0
Magnesium	Upper	3/3	3,010 - 4,240	3,460	NA	NL	NA
	Lower	1/1	2,960	NA	NA	NL	NA
Manganese	Upper	3/3	368 - 1,050	605	1,210	160	0
	Lower	1/1	355	NA	NA	480	0
Mercury	Upper	3/3	0.17 - 0.52	0.32	0.63	2.3	0
	Lower	1/1	0.20	NA	NA	1	0
Nickel	Upper	3/3	4.6 - 16.1	12.2	24.5	160	0
	Lower	1/1	7.2	NA	NA	65	0
Potassium	Upper	3/3	859 - 2,010	1,400	NA	NL	NA
	Lower	1/1	1,430	NA	NA	NL	NA
Selenium	Upper	2/3	0.51 - 1.1	0.81	1.24	39	0
	Lower	0/1	NA	NA	NA	2.6	NA
Silver	Upper	1/3	0.31	NA	0.41	39	0
	Lower	0/1	NA	NA	NA	17	NA
Sodium	Upper	3/3	551 - 2,530	1,750	NA	NL	NA
	Lower	1/1	2,430	NA	NA	NL	NA
Tin	Upper	1/3	46	NA	39.1	4,700	0
	Lower	0/1	NA	NA	NA	5,500	NA
Vanadium	Upper	3/3	18.8 - 51.2	38	75.9	55	0
	Lower	1/1	29	NA	NA	3,000	0

Table 10.11.5
Clouter Island Background Samples
Inorganics Detected In Soil (mg/kg)

Parameter	Sample Interval	Detection Frequency	Detection Range			Mean	Background Concentration	RBC (upper) SSL (lower)	Number of Samples Exceeding: RBC and Background (upper) or SSL and Background (lower)
Zinc	Upper	3/3	84.4	-	145	118	236	2,300	0
	Lower	1/1		57.5		NA	NA	6,200	0

Notes:
a = RBC for arsenic as a carcinogen
b = RBC for lead is not available. The USEPA residential soil cleanup level was used for comparison (OSWER Directive 9355.4-12).
NA = Not available/not applicable/not analyzed
NL = Not listed

Volatile Organic Compounds in Soil

No VOCs were detected in background soil samples at Naval Annex or Clouter Island.

Semivolatile Organic Compounds in Soil

Six semivolatile organic compounds were detected in Naval Annex background soil samples. Three (pyrene, fluoranthene, and phenanthrene) of these compounds were detected in one upper-interval soil sample (GDKSB00701). These compounds were also detected in surface soils at AOC 698 approximately 200 feet east of boring GDKSB007. However, concentrations in boring GDKSB007 are several orders of magnitude lower than the RBC but are the same magnitude as the detections at AOC 698. This implies that all of these concentrations are likely representative of ambient condition. One of the compounds (phenol) was detected in another upper-interval soil sample (GDKSB00101). The other two compounds were detected in lower-interval soil samples: butylbenzylphthalate was detected in the lower-interval sample collected at GDKSB009, and bis(2-ethylhexyl)phthalate was detected in the lower-interval sample collected at GDKSB004. None of the SVOCs detected in the GDK samples was detected in more than one sample.

Six SVOCs were detected in Clouter Island background soil samples. One SVOC, bis(2-ethylhexyl)phthalate, was detected in the GDKSBCL1 upper-interval sample. All other SVOC detections were in the upper-interval sample collected at GDKSBCL301. None of the SVOC detections exceeded its corresponding screening level.

Pesticides and PCBs in Soil

Three pesticides (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT) were detected in Naval Annex background soil samples. 4,4'-DDE and 4,4'-DDT were detected in all of the upper-interval soil samples. 4,4'-DDD was detected in only one upper-interval soil sample. No pesticides were detected in the lower-interval soil samples. These concentrations likely represent historic widespread routine pesticide application at the Annex.

Two pesticides were detected in the background soil samples collected at Clouter Island. One of the pesticides (heptachlor epoxide) was detected in the GDKSBCL4 upper-interval sample. The other compound (4,4'-DDT) was detected in the GDKSBCL3 upper-interval sample. Neither pesticide was detected at a concentration exceeding its RBC.

No PCBs were detected in the background soil samples collected at Naval Annex. One PCB (Aroclor-1260) was detected in a background soil sample (GDKSBCL101) collected at Clouter Island. The PCB concentration in this sample did not exceed its RBC.

Other Organic Compounds in Soil

Dioxin compounds were detected in the two Naval Annex lower-interval duplicate soil samples. TEQs for both samples were below the RBC of 4.3 ng/kg and the calculated SSL of 1,600 ng/kg.

Dioxin compounds were detected in each of the Clouter Island background soil samples. The TEQs for these samples were below the RBC of 4.3 ng/kg and the SSL of 1,600 ng/kg.

TPH (DRO) compounds were detected in eight of nine surface-interval and two of nine lower-interval background soil samples collected at Naval Annex. None of the detections exceeded the project screening level of 100,000 μg/kg. The highest concentration (74,400 μg/kg) occurred in sample GDKSB00101.

Inorganics in Soil

Twenty-two metals were detected in the Naval Annex background soil samples. Aluminum, arsenic, and iron exceeded their respective RBCs, although iron was the only one that also exceeded its background concentration.

Twenty-two metals were also detected in the Clouter Island background soil samples. Aluminum, arsenic, iron, and manganese exceeded their respective RBCs. None of these exceeded their respective background concentrations.

10.11.3 Groundwater Sampling and Analysis

The final RFI work plan proposed two shallow grid monitoring wells at Naval Annex. Both of these wells were installed (Figure 10.11.1). As proposed, shallow groundwater samples were analyzed for the standard suite of parameters plus TPH. The standard suite of parameters consists of VOCs, SVOCs, metals, cyanide, pesticides, and PCBs at DQO Level III. Second-round samples were also analyzed for the same parameters. Third and fourth-round samples were analyzed for the full suite of parameters minus TPH, based on results from the first and second rounds. Table 10.11.6 summarizes background groundwater sampling.

One temporary monitoring well was installed at Clouter Island to provide data for background comparison. The first-round sample from this well was analyzed for Appendix IX analytical parameters. The second, third, and fourth-round groundwater samples were analyzed for an abbreviated list (VOCs, SVOCs, metals, cyanide, and dioxins) of analytical parameters based on first-round detections.

Table 10.11.6
Background Locations
Groundwater Sampling Summary

Event	Samples Proposed	Samples Collected	Sample Analyses	Comments
Naval Annex (two shallow monitoring wells)				
January 1997 (1st round)	2 shallow	2 shallow	Standard Suite and TPH	None
April 1997 (2nd round)	2 shallow	2 shallow	Standard Suite and TPH	None
July 1997 (3rd round)	2 shallow	2 shallow	Standard Suite	Reduction of analytical parameters due to nondetects in first two rounds.
October 1997 (4th round)	2 shallow	2 shallow	Standard Suite	Reduction of analytical parameters due to nondetects in first two rounds.
Clouter Island (one temporary shallow monitoring well)				
May 1997 (1st round)	1 shallow	1 shallow	Appendix IX	None
July 1997 (2nd round)	1 shallow	1 shallow	VOCs, SVOCs, metals, cyanide, and dioxin	Reduction of analytical parameters due to nondetects in first round.
December 1997 (3rd round)	1 shallow	1 shallow	VOCs, SVOCs, metals, cyanide, and dioxin	Reduction of analytical parameters due to nondetects in first round.
March 1998 (4th round)	1 shallow	1 shallow	VOCs, SVOCs, metals, cyanide, and dioxin	Reduction of analytical parameters due to nondetects in first round.

Notes:
Standard Suite = VOCs, SVOCs, metals, cyanide, pesticides, and PCBs.
Appendix IX = Standard Suite plus hex-chrome, OP pesticides, herbicides, and dioxins.

10.11.4 Nature and Extent of Chemicals Detected in Groundwater

Table 10.11.7 summarizes the organic analytical results for groundwater at Naval Annex. Table 10.11.8 summarizes the organic analytical results for groundwater at Clouter Island. Table 10.11.9 summarizes inorganic analytical results for groundwater at Naval Annex. Table 10.11.10 summarizes inorganic analytical results for groundwater at Clouter Island.

Organic Compounds in Groundwater

Only one organic compound (BEHP) was detected in the shallow background monitoring wells at Naval Annex. It was detected in well GDKGW001 in a fourth-round sample only.

Dioxins/furans were the only organic compounds detected in the background monitoring well installed at Clouter Island.

Table 10.11.7
Naval Annex Background
Organics Detected In Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap water RBC/MCL	Number of Samples Exceeding RBC or MCL
Semivolatile Organic Compounds (2 shallow samples collected in each round)						
bis(2-Ethylhexyl) phthalate (BEHP)	First (Jan. 97)	0/2	NA	NA	4.8/NL	NA
	Second (April 97)	0/2	NA	NA		NA
	Third (July 97)	0/2	NA	NA		NA
	Fourth (Oct. 97)	½	1.00	NA		0

Notes:
NA = Not available/Not applicable/not analyzed
NL = Not listed

Table 10.11.8
Clouter Island Background
Organics Detected In Groundwater (pg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/MCL	Number of Samples Exceeding RBC or MCL
Organic Compounds (1 shallow sample collected in each round)						
No organics other than dioxins/furans were detected in the four rounds of shallow groundwater sampling.						
TCDD TEQs	First (May 97)	1/1	0.00886	NA	0.45/30	0
	Second (July 97)	1/1	0.07635	NA		0
	Third (Dec. 97)	1/1	0.11300	NA		0
	Fourth (Mar. 98)	0/1	NA	NA		NA
1234678-HpCDD	First (May 97)	0/1	NA	NA	45/NL	NA
	Second (July 97)	1/1	3.74	NA		NA
	Third (Dec. 97)	0/1	NA	NA		NA
	Fourth (Mar. 98)	0/1	NA	NA		NA
1234678-HpCDF	First (May 97)	0/1	NA	NA	45/NL	NA
	Second (July 97)	1/1	1.41	NA		NA
	Third (Dec. 97)	0/1	NA	NA		NA
	Fourth (Mar. 98)	0/1	NA	NA		NA
OCDD	First (May 97)	1/1	8.86	NA	450/NL	NA
	Second (July 97)	1/1	21.8	NA		NA
	Third (Dec. 97)	1/1	113	NA		NA
	Fourth (Mar. 98)	0/1	NA	NA		NA

Table 10.11.8
Clouter Island Background
Organics Detected In Groundwater (pg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/MCL	Number of Samples Exceeding RBC or MCL
OCDF	First (May 97)	0/1	NA	NA	450/NL	NA
	Second (July 97)	1/1	3.05	NA		NA
	Third (Dec. 97)	0/1	NA	NA		NA
	Fourth (Mar. 98)	0/1	NA	NA		NA

Notes:
NA = Not available/Not applicable/not analyzed
NL = Not listed

Table 10.11.9
Naval Annex Background
Inorganics Detected In Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and background
Inorganics (2 shallow samples collected in each round)							
Aluminum	First (Jan. 97)	½	9,490	NA	3,700/NL	471	1
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	½	391	NA			0
Barium	First (Jan. 97)	2/2	12.2 - 65.2	38.7	260/2,000	31.2	0
	Second (April 97)	2/2	10.7 - 20.7	15.7			0
	Third (July 97)	½	28.8	NA			0
	Fourth (Oct. 97)	2/2	6.7 - 25.9	16.3			0
Calcium	First (Jan. 97)	2/2	2,090 -8,640	5,365	NL/NL	NA	NA
	Second (April 97)	½	5,110	NA			NA
	Third (July 97)	2/2	1,630 - 2,450	2,040			NA
	Fourth (Oct. 97)	2/2	1,970 - 2,410	2,190			NA
Chromium	First (Jan. 97)	½	10.7	NA	11/100	NA	0
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	0/2	NA	NA			NA
Cobalt	First (Jan. 97)	½	1.5	NA	220/NL	NA	0
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	0/2	NA	NA			NA

Table 10.11.9
Naval Annex Background
Inorganics Detected In Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and background
Inorganics (2 shallow samples collected in each round)							
Copper	First (Jan. 97)	½	4.8	NA	150/1,300	2.81	0
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	½	1.30	NA			0
Iron	First (Jan. 97)	2/2	239 - 2,800	1,520	1,100/NL	235	1
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	½	225	NA			0
	Fourth (Oct. 97)	2/2	64.3 - 106	85.15			0
Lead	First (Jan. 97)	2/2	1.9 - 6.1	4	15/15	1.94	0
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	0/2	NA	NA			NA
Magnesium	First (Jan. 97)	2/2	210 - 1,830	1,020	NL/NL	NA	NA
	Second (April 97)	2/2	200 - 1,250	725			NA
	Third (July 97)	2/2	155 - 988	571.5			NA
	Fourth (Oct. 97)	½	838	NA			NA
Manganese	First (Jan. 97)	2/2	5.9 - 66.6	36.3	73/NL	9.33	0
	Second (April 97)	½	13.8	NA			0
	Third (July 97)	2/2	1.30 - 6.70	4.0			0
	Fourth (Oct. 97)	0/2	NA	NA			NA
Nickel	First (Jan. 97)	½	6.4	NA	73/100	NA	0
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	0/2	NA	NA			NA
Potassium	First (Jan. 97)	½	2,670	NA	NL/NL	NA	NA
	Second (April 97)	½	1,680	NA			NA
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	2/2	452 - 645	548.5			NA
Sodium	First (Jan. 97)	½	1,230 -3,460	2,345	NL/NL	NA	NA
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	0/2	NA	NA			NA
Tin	First (Jan. 97)	½	53.8	NA	2,200/NL	102	0
	Second (April 97)	½	196	NA			0
	Third (July 97)	0/2	NA	NA			NA
	Fourth (Oct. 97)	0/2	NA	NA			NA

Table 10.11.9
Naval Annex Background
Inorganics Detected In Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and background
Inorganics (2 shallow samples collected in each round)							
Vanadium	First (Jan. 97)	½	9.4	NA	26/NL	0.8	0
	Second (April 97)	0/2	NA	NA			NA
	Third (July 97)	½	0.76	NA			0
	Fourth (Oct. 97)	0/2	NA	NA			NA

Notes:
NA = Not available/not applicable/not analyzed
NL = Not listed

Table 10.11.10
Clouter Island Background
Inorganics Detected In Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and background
Inorganics (1 shallow sample collected in each round)							
Arsenic	First (May 97)	1/1	9.4	NA	0.045/50	15.1	0
	Second (July 97)	1/1	5.8	NA			0
	Third (Dec. 97)	1/1	6.8	NA			0
	Fourth (Mar. 98)	1/1	8.1	NA			0
Barium	First (May 97)	1/1	61.9	NA	260/2,000	95.9	0
	Second (July 97)	1/1	54.7	NA			0
	Third (Dec. 97)	1/1	46.1	NA			0
	Fourth (Mar. 98)	1/1	29.1	NA			0
Cadmium	First (May 97)	0/1	ND	NA	1.8/5	0.4	NA
	Second (July 97)	1/1	0.36	NA			0
	Third (Dec. 97)	0/1	NA	NA			NA
	Fourth (Mar. 98)	0/1	NA	NA			NA
Calcium	First (May 97)	1/1	485,000	NA	NL/NL	NA	NA
	Second (July 97)	1/1	455,000	NA			NA
	Third (Dec. 97)	1/1	420,000	NA			NA
	Fourth (Mar. 98)	1/1	332,000	NA			NA

Table 10.11.10
Clouter Island Background
Inorganics Detected In Groundwater (μg/L)

Parameter	Sampling Round	Detection Frequency	Detection Range	Mean	Tap-water RBC/ MCL	Shallow Groundwater Background	Number of Samples Exceeding Lower of RBC or MCL and background
Copper	First (May 97)	0/1	NA	NA	150/1,300	5.78	NA
	Second (July 97)	0/1	NA	NA			NA
	Third (Dec. 97)	1/1	5.9	NA			0
	Fourth (Mar. 98)	1/1	4.6	NA			0
Iron	First (May 97)	1/1	6,250	NA	1,100/NL	9,170	0
	Second (July 97)	1/1	4,710	NA			0
	Third (Dec. 97)	1/1	2,580	NA			0
	Fourth (Mar. 98)	1/1	4,800	NA			0
Magnesium	First (May 97)	1/1	327,000	NA	NL/NL	NA	NA
	Second (July 97)	1/1	305,000	NA			NA
	Third (Dec. 97)	1/1	265,000	NA			NA
	Fourth (Mar. 98)	1/1	163,000	NA			NA
Manganese	First (May 97)	1/1	976	NA	73/NL	1,210	0
	Second (July 97)	1/1	820	NA			0
	Third (Dec. 97)	1/1	311				0
	Fourth (Mar. 98)	1/1	322				0
Nickel	First (May 97)	0/1	NA	NA	73/100	2.84	NA
	Second (July 97)	0/1	NA	NA			NA
	Third (Dec. 97)	1/1	3.5	NA			0
	Fourth (Mar. 98)	0/1	NA	NA			NA
Potassium	First (May 97)	1/1	95,300	NA	NL/NL	NA	NA
	Second (July 97)	1/1	99,900	NA			NA
	Third (Dec. 97)	1/1	74,400	NA			NA
	Fourth (Mar. 98)	1/1	55,800	NA			NA
Sodium	First (May 97)	1/1	2,300,000	NA	NL/NL	NA	NA
	Second (July 97)	1/1	2,390,000	NA			NA
	Third (Dec. 97)	1/1	1,910,000	NA			NA
	Fourth (Mar. 98)	1/1	1,100,000	NA			NA
Tin	First (May 97)	1/1	39.8	NA	2,200/NL	34.6	0
	Second (July 97)	0/1	NA	NA			NA
	Third (Dec. 97)	0/1	NA	NA			NA
	Fourth (Mar. 98)	0/1	NA	NA			NA
Vanadium	First (May 97)	1/1	5.9	NA	26/NL	9.1	0
	Second (July 97)	1/1	5.0	NA			0
	Third (Dec. 97)	1/1	4.0	NA			0
	Fourth (Mar. 98)	1/1	3.3	NA			0

Notes:
NA = Not applicable/not available/not analyzed
NL = Not listed

Inorganics in Groundwater

Fifteen metals were detected in the Naval Annex background groundwater samples during the four sampling rounds. Aluminum and iron were detected exceeding their respective RBCs and background concentrations in the first-round sample from well GDKGW01.

Thirteen metals were detected in the Clouter Island background groundwater samples during the four sampling rounds. None exceeded both of their respective screening levels.